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EDITORIAL.

ITEMS AND NOVELTIES.

The Louisville Bridge.—In our October number we gave a brief description of the character and progress of the bridge in course of construction over the Ohio River, at Louisville, Ky., and stated that, in all probability, it would be ready for the passage of trains during the month of November. We are sorry to learn that the progress of this work has been greatly retarded by the extremely bad weather of October and November, and that its completion has been materially delayed by an unforseen accident, by which the falsework for erecting the last span was lost. The masonry was completed in the latter part of November, and on the 1st of December all the spans were in place except one of 245·5 feet, adjoining the 400 feet span over the Indiana Channel. The falsework for this last span had been raised, and everything was ready to commence putting on the iron of the super-structure. At this time reports were received that the river was rising all the way from Louisville to Pittsburg. As it was impossible to secure the iron work before the water would reach its highest point, it was thought advisable to suspend the putting on of iron, weight the falsework with stone and wait the action of the water and drift for a few days. On the morning of the 5th a light salt boat was blown from her course and lodged against the trestles, knocking a portion of the foundations from two; the water was now at its highest stage, and the officers of the Bridge Company were congratulating themselves on the prospect of being able to repair this slight damage as soon as the water fell a little, and go on with the work; all these anticipations were turned to disappointment, for on the morning of December 7th, a steamboat with a tow of barges, started over the falls in the fog, missed the channel, struck the falsework, and knocked it down; the trestles carried with them the cribs on which they were supported, leaving a clear gap of 245·5 feet width, at the bottom of which was an almost irresistible body of water having a velocity of 16 miles per hour and a depth of 16 feet.

The 400 feet span was swung on its pier bearings November 27, barely escaping the dangers of this flood; the top falsework of this span was taken down and sent on shore, while the bottom consisting of five large towers was pulled over into the river and allowed to float away, it being of great importance to open the channel to navigation with the least possible delay.

This is the longest iron truss yet erected in America, and with the 370 feet span over the middle channel constitutes an array of constructive details of great interest to all interested in bridge construction.

These channel spans are of the "triangular plan" as arranged by Mr. Fink, and in vertical position are "over-grade" or "through" having a clearance above low water line of 90 feet in the middle, and 96½ feet in the Indiana Channel, each span consists of four trusses 46 feet deep, each complete in itself, arranged two on either side of the roadway. The distance between centres of the trusses forming the pairs is 34 inches in the 370 feet span and 41 inches in the 400 feet. The distances from the dividing lines of these pairs of trusses transversely are respectively 25 feet and 25 feet 7 inches, the flooring being supported on trussed 12 inch beams at intervals, longitudinally, of 15 feet 4 inches in 370 feet and 14 feet 3 inches in 400 feet span, clear width of roadway 20 feet 6 inches.

Each truss was swung on its pier supports independent of the others, the object being to avoid undue strain from any irregularity there might be in workmanship, by allowing each truss to take its natural curve; happily no perceptible difference was found in the four curves of either span, and in both, the trusses were bolted to each other, without chipping or reaming of the bolt holes, each span has a cambre at the centre of 4 inches; they give entire satisfaction to their engineers, Messrs. Albert Fink and F.W.Vaugham, and are admired for their lightness and simplicity by all who have examined them. Since the accident the engineers have been resolutely at work repairing damages, the frequent rises and disagreeable weather of this time of year prevent such rapid progress as might be expected in summer. The plan for the new falsework is such as to do away with the difficult work of sinking cribs in the swift water as far as practicable; one crib 14 feet wide and 50 feet long has been sunk in the middle of the space, on this crib three trestles will be erected, one vertical and one leaning towards either pier, supported on each pier will be erected a trestle leaning towards one on the centre crib. These trestles will be leaned so as to be connected by a fifty feet truss on top, forming a huge straining beam of 122 feet 9 inches span.

It is confidently hoped that this last span will be in place by the 1st of February 1870.

Powerful Turbines.—A correspondent of the *American Odd Fellow*, thus describes the turbines used in the Mastodon Mill, in the village of Cohoes, New York.

"The entire number of looms in this mill is fourteen hundred and eighty-six; five hundred of which are located on the first floor."

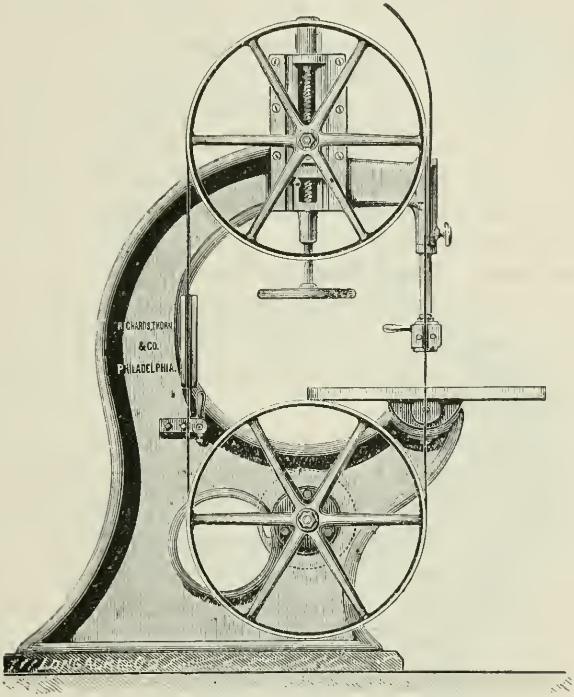
These looms and the other machinery of the mill are driven by three "immense turbine water wheels, made by the Ames Manufacturing Company, which operate the main shaft, and possess an aggregate driving capacity of over eleven hundred horse-power. This pit having an extreme depth of forty feet, with a floor twenty-five feet from the surface, which hides the water wheels from a top view, is, in reality, an under-ground two story building. Three mammoth cast iron cylinders, eight feet each in diameter, convey the water from the canal on the west side of the building to the wheels; the volume of water being regulated by a sort of tiller located in the pit, and connected with flood-gates. The perpendicular shaft of each turbine is connected with the main shaft by beveled gear, and the united power exerted, if so applied, would reverse the motion of the great Burden water wheel at Troy, and drive the machinery of a good sized manufactory besides. The shaft to which this wondrous power is applied is supported by three granite abutments, and forms the axis of six ponderous driving pulleys, twelve feet each in diameter. The immense belts which radiate to all parts of the building are in keeping with the massive pulleys and gearing. These are each two feet wide, and the longest one reaching to the fifth story, measures nearly two hundred feet. At the north end of the pit, two rotary force pumps are located, which in case of fire, can be instantly geared to the main shaft by means of a sliding cog wheel, and are jointly capable of throwing six thousand gallons of water per hour."

The Endless or Band Sawing Machine has now a history of some fifteen years. The first general use of these saws was in Great Britain and France where they are extensively employed for cutting wood, and have, in some instances, been successfully applied to cutting metal.

During five years past this machine has been largely introduced in the United States; and the rapid and perfect manner in which it cuts irregular lines for wood work, and the consequent reduction in the cost of such sawing, has not only attracted general attention, but led to a more extended use of scroll-sawed designs in carpentry and furniture, softening what might be called the angularity of our work in both wood and metal, an improvement for which there is certainly room in the patterns for castings generally made in this country.

The popular impression as to the perishable nature of the saws, is fast giving away before the improvements made in their manufacture, and the greater experience in operating them, of which we will speak further on.

The invention, or rather the introduction of Band Saws should, in the natural course of these arts have come from the United States, where wood as a material enters so largely into our manufactures; and its earlier use in Europe can only be accounted for by the greater experience in preparing steel for the saws, and perhaps by the partiality of English manufacturers and merchants for a machine that could be sent to their distant markets with the assurance that it could be operated for a long time without repairs, and in places where there was but little mechanical skill—but the reason is not important—the fact of the general and extended use of Band Saws, in those parts of the world, including our own country, where there has been the greatest amount of attention given to improvements in machinery, justifies the proposition that the Band Saw is no longer an experiment.

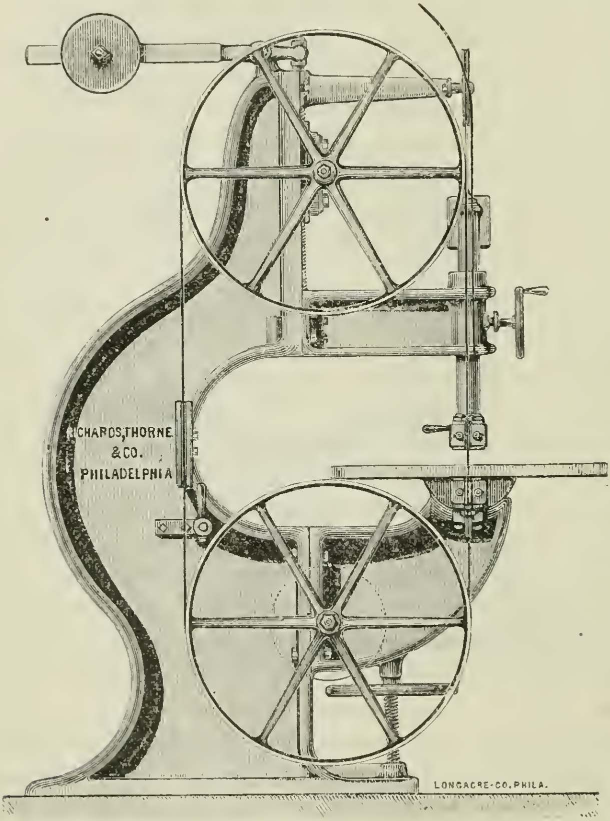


No. 2.

The action of the saw is continuous and corresponds to that of the circular saw, with the difference that the cut is at right angles with the face, or square through the stuff, and the dust is all carried down through the kerf, leaving the top surface clean, enabling the operator to follow the line with precision.

The Band Saw or Blade can be made much thinner than those used in the reciprocating machines, and can generally be passed through the piece for inside or perforated work without leaving a kerf wide enough to difigure the work.

The chief characteristic of Band Sawing Machines is their simplicity when considered with reference to the variety of work they can perform. There are no slides nor reciprocating parts, and consequently there is no jar or vibration. The manufacturer is not, as in reciprocating machines, limited to a minimum weight of those parts of his machine which he would otherwise make the strongest. The motion is rotary and the bearings are those of plain shafts, with no limit as to length or diameter; while the speed is much slower than the spindles in other wood-cutting machines.



No. 4.

The illustrations show two machines from the designs of Richards, Thorne & Co., of Philadelphia, on which there are patents pending for important improvements.

Mr. Richards, the senior member of the firm, has visited England and France to investigate the history of these and other wood-cutting machines in those countries, and is the patentee there of the improvements in Band Sawing Machines, illustrated in a late number of *Engineering*, from the drawings of Messrs. Allen Ransome & Co., of London, who are the most prominent manufacturers of sawing machinery in England.

The machines herewith illustrated are built in the strongest manner, the frames being cast in one piece with sufficient metal in their cross section to withstand the strain of the saw and prevent vibration in the frame.

The devices for guiding and supporting the saw are of a new and efficient character consisting of a cylinder of hardened steel with its axis parallel with the saw blade, against which the back of the saw runs. This cylindrical back support can be rotated so as to bring any part of its periphery in contact with the saw-blade, and has a sufficient diameter to present about one hundred independent wearing surfaces. The lateral guides are also of hardened steel, and are arranged to be instantly adjusted for saws of different widths.

On the No. 4 Machine, the straining devices that regulate the tension of the saw-blade, act by means of a weight, which weight has a peculiar adaptation to the purpose when arranged to act independently of the adjustment of the top wheel, and maintains an uniform strain of the saw when adjusted to suit its width.

The table of this machine can be set at various heighths from the floor to suit the character of the work and the convenience of the operator. As the top of the lumber should always be at the same heighth, this feature is very important when both deep and thin sawing is done on the same machine. A compensating arrangement can be applied to the driving belt and the table continually adjusted to suit the depth of the work by means of the hand-wheel seen in the drawing; or two different belts can be used, one for deep and the other for thin sawing, the change from one to the other being conveniently performed by raising or lowering the bracket. When the machine is set on an upper floor or when it is desirable to have the lower wheel run above the floor, or in any case where a considerable adjustment is not needed, this arrangement is of great importance as a means to regulate the tension of the belt to suit the depth of the work and prevent unnecessary strain on the driving shaft when light work is being done. This is a feature that should, whenever practicable, be introduced in belted machines.

The top wheel is adjusted by the hand-wheel in the front of the operator. This is connected by gearing with the adjusting screw, and so arranged as to be at all times within easy reach.

The table is arranged to set at different angles for bevel sawing and has in some of the English machines been moved by automatic mechanism for spiral cutting, and when combined with a co-operating feed movement answers an excellent purpose in cutting out ship timbers.

The shield or guard seen in the engraving over the top wheel, protects the operator in case of the saws breaking.

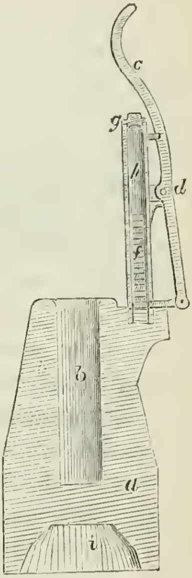
The No. 2 Machine, illustrated, like the other, has a frame cast in one piece. It is fitted with an elastic straining device and has all the functions necessary for the smaller class of shops where a cheaper machine is wanted.

It will be noticed that the wheels have no flanges to keep the saws on,—the conditions being the same as a belt running on a pulley. It would be superfluous to explain this farther than to say that it prevents the saws from being bent or curved in the direction of their deep section, and also prevents them from being twisted by rubbing against the flanges, two things that may be safely set down as the principal cause of their breaking. For sawing metal the machines require no change except the addition of proper appliances to regulate the speed of the saw which, however, need have no relation to the ordinary speed of metal-cutting tools. The teeth after each cut are cooled by traveling a long distance through the air, and thus avoid the conditions that limit the speed of cutting tools that act continuously or at rapid intervals.

To close this article we will revert to the popular hobby of saws breaking, which has done so much to deter manufacturers from adopting these Band Saws. The saws do not break from cutting nor *from bending over the wheels*, but from a neglect of, or an ignorance of their care, and from bad construction in the machines to operate them; and it will be safe to assert that a Band Saw blade will, under favorable conditions, *do more cutting, in proportion to its cost, than even the circular saw.* It is but a few minutes work, with a good brazing apparatus, to join them if broken; and it is to be hoped that with a greater experience in their manufacture and operation, the brazing apparatus may be discarded, except by the saw maker.

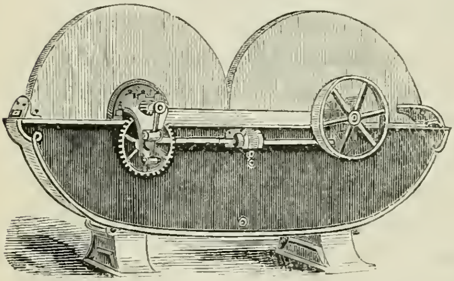
These machines are manufactured by Richards, Thorne & Co., Philadelphia, who may be addressed for particulars as to their operation and their application to the various uses for which they are adapted.

Gunpowder Pile Driver, self-feeding attachment.—At the last meeting of the Institute, there was exhibited by Mr. Thos. Shaw a device by which his Pile Driver was made automatic in its feeding arrangement. To accomplish this a shoulder is cast upon the upper end of the anvil or cylinder *a*, which rests on the head of the pile, and into which the ram plunger descends. Into this is screwed an upright tube, having an opening at the lower part just large enough to allow a cartridge to pass out at one side, and a sort of plunger or pawl, by which the cartridge is expelled, to enter at the opposite side. This opening is continued across the adjacent edge of the cylinder into its mouth. Upon this tube is supported a lever *c d*, whose upper end is so bent that a cam on the plunger will, in descending, drive it back, so shooting a cartridge into the cylinder and, the cam being of sufficient length, the lever will be held back and the small plunger made to close the orifice of the tube until the ram has reascended above the lever, thus preventing risk of ignition of the cartridge in the tube, by the explosion in the cylinder. A spring placed below the fulcrum *d*, returns the lever to its place after the ascent of the ram. The cartridges are, of course, placed in the tube *f g*.



Improvements in Grindstones.—By Mr. J. E. Mitchell.—At the last meeting of the Institute there were exhibited several improvements in the mounting of grindstones, by Mr. Mitchell, whose experience, during many years, has enabled him to bring to great perfection all the details involved in the most successful preparation and use of this indispensable tool. By the application on an extensive scale of steam machinery, the time required for shaping these stones has been greatly decreased, and the ability of increase in the size of those which could be prepared and were desirable for certain uses has been greatly enlarged, so that small stones may now be turned out in a few hours, and sizes as great as 5,000 lbs. in weight are brought within the possibilities of the art.

Among the novelties in methods of mounting and driving, exhibited on the occasion above mentioned, were, in the first place, the arrangement for small stones, by which at once a high velocity was given and the band placed out of reach of injury from the knife or other article which was being ground. This was accomplished by a simple system of gearing placed in the support below the axis of the stone, and protected by a casing.



Another novelty consisted in the combination of two stones with opposite directions of motion in such a way that they tend to keep each other perfectly true. This adjustment is illustrated in the accompanying woodcut which speaks for itself. In some cases this arrangement is found to be of great value, though, of course, for ordinary work, it would be unnecessary.

Non-polarization of the Corona.—Just after our last number was printed, we received from Prof. Pickering a note stating that he had heard from Prof. F. H. Smith, of the University of Virginia, that an instrument exactly like that used by him in observations of polarization during the eclipse, had been employed by a member of the party at Eden Ridge, Tenn., and with exactly the same result that he (Prof. Pickering) had obtained. We think that no one, after reading Prof. Pickering's note in our last number, p. 372, will feel any doubt about the accuracy of his observation, but, at the same time, such supporting evidence is of considerable value and renders his unexpected results yet more certain.

Projection of Spectra.—In a lecture on spectrum analyses, lately delivered by Dr. Barker, of New Haven, before the Young Men's Christian Association of Brooklyn, N. Y., a series of metallic spectra were projected on the screen with a success not before attained, we believe, in this country or abroad. From an eye-witness we have the following account:—

"The spectra-projections were simply superb. The battery used consisted of 50 cells of Bunsen, 12 inches high, all splendidly amalgamated and cleaned. A Duboscq lantern with his improved lamp which gives two directions of motion in the carbons, was employed. For holding the substances, pieces of Carbon ½ inch square and 2 inches long, fitting into the socket of the carbon-holder, were used, being hollowed out to receive the metal. The condensing lenses was protected by a plate of glass from the fiery rain of melted metal; otherwise these little globules fuse themselves into the lens, making it rough. The slit had a length of 1½ inches and was nearly an eighth broad. By moving the condensing lenses, the image of the carbon points was accurately focussed at a distance in front of the lantern equal to that of the screen. Then an *achromatic* lens on a stand, (the one used was made by Hoffman of Paris) having a focal length of 18 to 20 inches was placed before the lantern and so adjusted as to give a perfectly sharp image of the slit in place of the image of the points. At a distance from this, equal to that of the lantern—a point where the rays can be seen to cross—the prisms were situated. They had a clear space of two inches, were made of thick glass tube cut obliquely so as to give prisms of 60°. and having sides of plate glass. They were filled with bisulphide of carbon, and were enclosed in a suitable box to prevent irregular emisions of light, as well as for convenience of transportation. The receiving face of the first prism received the beam of light centrally; then moving the box about the vertical axis of this face as a centre, the spectrum permitted adjustment to the angle of minimum deviation. In this way, with the battery power given above, a splendid continuous spectrum ten feet long by 18 inches wide was obtained, overlapping the screen 9 feet by 3 at both ends. There were then projected the spectra of sodium, lithium, magnesium, copper, brass, iron, mercury and thallium, using the metals, except in the case of lithium, where the carbonate was used. The regulator worked so perfectly that the spectra could be held at pleasure; that of thallium remaining constant for at least five minutes. The lines were as sharply cut as in the spectroscope; they were slightly curved—an inch or so in the eighteen only—owing, undoubtedly, to the fact that all the rays do not strike the prism exactly at the angle of minimum deviation. Six lines were observed with sodium, probably those noticed by Wolf and Diacon (C. R. lv, 334;) three lines with lithium, the blue being gorgeous. The copper brands were beautiful and retained their identity perfectly when the zinc lines in brass were added to them. The numerous lines of iron came out with a surprising minuteness, the dark spaces between them looking in some places like fine black lines. Mercury gave three lines only; one a peculiar light orange-yellow—a sort of nankeen color—the second green, the third a splendid blue-violet. It was very striking to sit down before this spectrum, with the ordinary spectroscope at hand, before the slit of which was a vacuum tube containing mercury, warming this till the spark would pass and then examining the two spectra by comparison. They were absolutely identical in character, even in sharpness. The reversal of the sodium line is readily shown simply by placing before the slit—the carbon points of course being arranged for a continuous spectrum—an ordinary Bunsen burner on the mantle of which is placed a bead of salt on a loop of platinum wire."

Sinking Screw Piles.—A machine has been lately designed by an English firm at the request of H. Lee Smith, Esq., chief engineer for the Punjaub Northern Railway, for screwing down piles to be used in constructing bridges and flood openings on that line of railway. This machine consists of a wrought iron under carriage mounted upon wheels of 5 feet 6 inches gauge, and carrying a vertical boiler at one end. A strong cast iron beam in the centre carries a cylinder in which works a ram, to the top of which a strong cross-beam is bolted which carries the machinery for operating on the piles. This consists of a horizontal steam engine bolted to the side of the cross-beam, and driving a pinion and train of spur and bevel wheels which impart motion to two large horizontal wheels carried in bearings at each end of the cross-beam. A friction clutch is carried in the centre of each of the wheels, through the boss of which the shaft of the pile to be screwed is passed. The shafts are rolled with feathers or ribs on each side, which, passing through corresponding recesses or keyways formed in the boss of the friction clutch, form the means of imparting motion from the horizontal wheels to the piles, steam is brought from the boiler, through the centre of the ram and cylinder which carries the cross-beam, by means of a telescope joint, which allows the ram to be raised without interfering with the steam pipe; and a small donkey engine is provided which can pump from a tank situated between the frame, either into the boiler or into the cylinder under the ram which carries the cross-beam. When the machine is at work the cross-beam is held firmly by means of cotter bolts to the frame. The modus operandi is as follows:—A temporary road being laid on the centre line of the proposed structure, piles are pitched by passing the shafts through the wheels on each side of the machine, and keying them into screws which are placed in a small hole excavated to receive them. The engine is then set to work, and the piles screwed down as far as possible. The cotters holding the crossbeam are then removed, and it is raised by the donkey engine pumping into the cylinder of the machine, and lifted off the piles. The machine is then moved forward to the centre line of the next pile, and the operation takes place as before.

Editorial Correspondence.

PUMPING ENGINES.

THERE have appeared in your valuable *Journal* quite a number of articles, within the past eighteen months, upon this important subject. It is one in which all our cities are especially interested, and its discussion can not fail to prove beneficial.

In the November number of your *Journal*, was an article over the signature of W. M. Henderson, hydraulic engineer, which shows an extended knowledge of the subject.

Like him I have been looking for some further information about that "other engine based upon reciprocating parts, without a fly-wheel which possessed the capacity of rivalling the Cornish in its best results, without the requirements of magnitude demanded by that engine."

From the remarks of Mr. Henderson, in regard to this "other engine"—it appears that it is now being built for the new water works in West Philadelphia—and most of us have heard of this engine under the name of the "Worthington Duplex."

Very many of these, of moderate size, are in operation throughout the country, and generally, I believe, working with little noise, and little repairs, and with great satisfaction to the owners.

If to their satisfactory operation, as to repair and general efficiency, the authorities of our great cities could be informed *with certainty* as to their economy in fuel—as to the "*duty*" they perform when compared with the cornish, many of the city fathers would be greatly relieved. For who does not know the deep anxiety of these gentlemen, in all the great municipalities of the land, to economize *in machinery*, that the load of taxes on the people may be light.

When that West Philadelphia engine then shall be completed, it may be expected that a vigorous test of their performance shall be made; and the duty performed, everywhere reported. This can not fail to be done, as these rather insignificant looking machines have so much pretension; and even aspire to rank with the Cornish in economy of result.

But while we are patiently waiting the completion and test of these engines, it would give great satisfaction to many of your readers if the duty of the *Cornish Engines in this Country*, or even in Philadelphia, could be given in your columns.

Those reported by Mr. Henderson as a basis of comparison in the coming trial of the Duplex are too distant for a satisfactory comparison—other fuel is used, other kinds of boilers, probably—and, perhaps, a different rule of computation.

Cannot some of your contributors furnish the result of the Cornish engines here in Philadelphia for such a comparison. Cannot Mr. Henderson supply them?

As giving some information, perhaps, now forgotten, that was published a few years since, when the subject of the pumping engines for the City of Brooklyn was under discussion, I copy the results of comparative tests carefully made at that time under the direction of experts.

		Pounds Raised One Foot High.	
		By one lb. of Coal.	By 112 lbs. of Coal
			MILLIONS.
Brooklyn Engine,	Double acting Beam Engine no fly wheel,	601,407	67·36
Belleville “	Cornish,	628,233	70·36
Hartford “	Crank,	587,793	65·83
“ “	“ 2d trial,	614,426	68 82
“ “	“ 3d trial,	646,994	72·46
Cambridge “	Worthington, 1st trial,	669,411	74·97
“ “	“ 2d trial,	675,746	75·68
Sp. Garden, Phila.	Cornish,	589,053	65·97

Taking the average of the two trials of the Cambridge engine at.........75 Millions.
And the average of the Belleville and Spring Garden Cornish engines at.................................68 “

Gives an excess of duty to the former of.................. 7 “

If, as is claimed by the advocates of the Worthington engines, a better result can be realized with engines of larger size than that at Cambridge, this class of engines may become a formidable rival even of the *Cornish*, which has so long maintained and so well deserved its pre-eminence. FULTON.

Civil and Mechanical Engineering.

PENNSYLVANIA RAILROAD GRAIN DEPOT, WEST PHILADELPHIA.

By Jos. M. Wilson, C. E. P. A., Engineer Construction Department P. R. R.

This building is located on the east side of 30th Street, just north of Market. It is intended as a depot for receiving grain directly from cars and delivering expeditiously into wagons by which it can be transported to the warehouses of the owners. It is 555 feet in length, 125 feet in width and 36 feet from ground line to eaves, being divided into two stories by a floor 19 feet above the ground line. The roof is a single span having a one-quarter pitch, and built of wrought iron, upon the simple triangular truss system, with timber principal rafters. It is covered with slate and has, at frequent intervals, sky-lights of hammered glass. The balance of the building is constructed entirely of timber, the sides being sheeted and slated. The total content, comprised within the outside walls and from ground line to slope of roof, is 3,607,500 cubic feet. The cars enter the second story by six tracks running its entire length. Between the tracks the platforms are 4 feet above the rail. Underneath, from the platforms down to eight feet above the lower floor or ground line, the whole of the space is put into bins. From the cars the grain is shoveled directly into upper openings in the bins, which are 11 feet apart on either side of each track. There is a sliding valve in each bin, at the bottom, by which the grain can be passed directly into wagons underneath by its own gravity, the sides of the bins being sloped at such an angle as will insure its delivery. The total number of bins in the building is 600, and the average capacity of each 500 bushels, giving a total capacity of 300,000 bushels. By a system of duplicate numbers on the upper and lower openings of bins, the grain of different shippers can be kept separate and distinct, and is transferred from car to wagon without confusion. Wagons enter the ground floor by 50 passage ways running in the direction of the width of the building and separated by trestles eleven feet apart, which support the upper floor. These passage ways are directly under the lower openings of the bins, and are closed by doors at each end. On the platforms between the tracks on second floor, flour in barrels may be unloaded, and at the east end of the building, on the outside, a block and tackle is arranged for each platform to facilitate lowering the flour to a wharf beneath.

The ground upon which the building is erected being artificially made, upon a bed of river mud of considerable depth, it was decided to use piles in the foundations. Excavation to the depth of six inches above ordinary high water was commenced in November, 1868. Upon this bottom, which was just above the level to which water came through the ground from the river, the pile drivers were placed. The first pile was driven November 30th, and the driving was continued at the following rates: December, 316; January, 655; February, 544; March, 428; April, 1079; May, 1184; June, 1352. Making a total of 5,558, of which 5,175 were under the main building and 383 under the. retaining walls of approaches. There were three pile drivers. Two were worked by engines stationed on the land and one by an engine on a scow on the river. Of the land engines, sometimes both were working and a part of the time only one. The river engine worked only occasionally, being used principally to hoist timber from the river. The supply of timber for piles was quite limited during the winter and gave out entirely in March, so that the driving had to stop until the spring freshets brought down a new lot. The piles along the east or river front were driven to an average depth of 33 feet below ordinary high water before reaching hard bottom. At 150 feet from the east end the average depth was 35 feet; at 300 feet, 34 feet; at 400 feet, 32 feet; at 450 feet, 24 feet; at 500 feet, 14 feet; at 520 feet, 6 feet; and from here to the west end of the building it increased to 19 feet. The piles were of straight growth Hemlock not less than ten inches diameter at the head, which was hooped with a wrought iron band. Under the outside walls they were driven in three rows, and under the interior or cross walls in two rows, being placed 2½ feet between centres across the rows, and three feet between centres lengthwise of the rows. After they were driven the earth was excavated around them to a debt of 2½ feet below ordinary high water, and they were sawed off at that elevation. A cap of flattened Hemlock logs, 9 inches thick and average 15 inches in width on face, was laid upon each row and pinned to the piles by locust pins. Upon this a second course of similar logs, not less than six inches in thickness, was placed crosswise and fastened, thus forming a floor upon which the masonry was built. The platforms of the cross walls were securely tied together by logs of the upper course at intervals of about every 15 feet. The masonry was commenced in March and followed up the pile driving closely. The outside walls are 4 feet thick at bottom, and are carried up to 10½ feet above ordinary high water, diminishing by steps to 2½ feet thickness at top. The cross walls are 3 feet thick at bottom, and are carried up to 12½ feet above ordinary high water, diminishing to 2 feet thickness at top. The whole of the foundations between the masonry was filled up with earth to one foot below top of cross walls, and on a level with 30th Street.

The tracks running on to second floor cross 30th Street by a wrought iron elliptical braced arch bridge of 64 feet 1 inch span and 11 feet 11¾ inches rise at the crown. Although not strictly novel in its design, yet it is believed to be the first of its kind put up in this country. It is hinged both at crown and springing, thus reducing the calculations to a certainty not possessed by the ordinary form of arch, and annulling the straining effects due to change of temperature or yielding of piers. The plans and specifications for both bridge and building were furnished complete by the Construction Department of the Pennsylvania Railroad, and the work executed under its superintendence, although the most of it was done by contract.

PERFORMANCES OF ENGINES.

By W. H. G. West, Engineer, U. S. N.

The following is a statement of the performances of a number of engines, collected from different quarters, by engineers of undoubted knowledge and integrity.

Condensing cotton mill engine at Chester, Pa. Diameter of cylinder 20″. Stroke 4 feet. Steam cut off about one foot from commencement of stroke. Steam pressure 61 pounds above atmospheric. Boiler, tubular: locomotive pattern. Coal consumed per horse-power per hour, 2·35 pounds. Duration of trial 60 hours. For one day of the trial the consumption was only 2·057 pounds per hour, for each horse-power. Chestnut coal gave the best result; and if used during the whole trial, would probably have brought the consumption below 2 pounds.

Non-condensing cotton mill engine. Diameter of cylinder 14″. Stroke 3 feet. Cut off at about ⅙ of stroke from commencement.

Cylinder boilers. Steam 80 pounds above atmospheric. Consumption of coal 3 pounds per horse-power per hour.

Condensing cotton mill engine. Diameter of cylinder 28″. Stroke 5 feet. Steam pressure 110 pounds above atmospheric. Cut off varied by regulator. Jacketed cylinder. Tubular boilers. Consumption of coal per horse-power per hour, 1·9 pounds.

Brooklyn Water Works Engine.—Diameter of cylinder, 90″ Stroke 10 feet. Flue boilers. Consumption of coal per horse-power per hour 3 pounds.

Average performance of a number of stationary engines of and about 20″ diameter of cylinder, 4½ pounds of coal per horse-power per hour.

Babcock and Wilcox engine, Jacketed, 3½ pounds.

Greene's engine, 3¾ pounds.

Corliss engine, non-condensing, 3½ pounds.

Average performance of a number of Cornish engines. Diameter of cylinders 50″ and upwards; about 3¾ pounds per horse-power per hour.

U. S. S. "Wampanoag," running 18 to 20½ statue miles per hour, after making all allowances for friction of load, etc., and so bringing it to the same condition, in regard to duty, as the Cornish engine, 3·129 pounds per horse-power per hour.

U. S. S. "Ammonoosuc," running 18 to 20 statue miles per hour, 2·65 pounds per horse-power per hour.

H. B. M. ship "Constance," *Woolfe* engines, with jacketed cylinders. Steam expanded from 8 to 10 times. Surface condenser. Consumption of coal per horse-power per hour, 2 pounds.

In presenting these proofs of the correctness of a former assertion that many American, and other rotative engines, will compare favorably with the majority of Cornish engines, I do not wish to imply that the above performances are the best obtained from the engines named, but that they are sufficient to prove more than equality. In collecting them, I have been forced to the conclusion, that either the construction of the Cornish engine is not particularly well understood, by the present manufacturers of that interesting machine, or that the old plan of guessing at coal, by the barrow load, led the experimenters, of that time, astray.

More than twenty years ago the duty was said to have come up to 130,000,000 pounds, lifted one foot high, by the consumption of 112 pounds of Coal; but for May, of this year, the average for eighteen of them was only 50,100,000, and it will be found that this is the general average.

Several writers have distinctly stated, in the *Journal*, that the weight of the moving parts is the principal cause of the superiority of this engine, and much importance is attached to the fact of its having a beam, but we know very well that the weights are nearly the same as in old times, and that the weight of the engine beam is exceedingly small, when compared with the weights of rods balance-beams, etc., which belong to the pumping apparatus, and which must be used with any kind of engine that may be employed. Can prejudice possibly be so strong as to compel any one, even to insinuate, that a slight variation, in the strength of parts, will make a difference of 80,000,000 pounds in the duty.

In accepting, as sound, the arguments of the gentlemen who have recently written so warmly and forcibly in favor of these engines; there is nothing left but to believe that those built in late years are very badly designed. Mr. William West, the designer of the 80″ at Fowey Consols, would not feel complimented, were he to hear that the success which he sought to achieve by improvement in every detail, was due to clumsy bulkiness.

It is stated in a paper upon steam jacketing that, *practically*, the expansion of metal is nothing, in the cornish engine cylinder. This is repeating the old story, that theory does not agree with practice, and is an expressed doubt of the ability of such men as Joule, Faraday, Tyndall, Regnault, and others of equally high reputation, to make practical experiments. A beautiful set of experiments is recorded in the November number for 1869, showing the number of vibrations of piano strings in making the different notes; but *practically*, we have every reason to doubt the truth of the statement, because we do not see the strings flap about, like the sails of a ship, tacking in a gale of wind.

At one end of the Cornish cylinder we have a high pressure, say 60 pounds, the temperature of which is 292·6 degrees, Fahr. and at the other end 90°—condenser temperature. Cast iron expands lineally .00000618 per unit, for each degree of heat added about these temperatures. An 80″ cylinder will therefore increase its diameter full 0·1 inch. The temperature of the piston will be a mean between the other two, and the thickness of the piston being about ten times greater than that of the cylinder, its temperature will not change as rapidly: indeed its diameter will be nearly constant. If it fits well at one end, it must therefore jam, or leak steam at the other. *Practically*, my attention was first drawn to it by one who had observed it in the Fowey Consols 80″ when an attempt was made to move her, before the steam, passing from the boiler to the jacket, had heated the cylinder all through. After steam had been admitted to the lower end, the engine worked as usual. The difference of temperatures, in that case, was probably 250° ; and the difference of diameters almost exactly ⅛ inch. In the same circumstances, the 110 inch cylinder, now being made for the Bethlehem Zinc Mine, Pa., would have a difference of diameter of over ⅙ inch; and the 144 inch built by Harvey and West, of Hayle Foundry, Cornwall, England, for Holland, would have a difference of diameters of 0·22 inch (nearly ¼″.) Would that be a *practical* leak? The very high steam that some people say is used in Cornish engines, would make the leak greater.

Rankine, in his "Prime Movers," page 568, compares the effects produced with, and without, the steam jacket. The ratio of whole gross work of steam to gross work during admission, will show which does the most work during expansion and will be

$$\frac{\text{mean pres.} \times \text{ratio of expansion}}{\text{initial pressure}} = 3{\cdot}55,$$

for the unjacketed cylinder, and 3·73 for the jacketed cylinder; showing decidedly in favor of the jacket. Condensation in the cylinder, is shown by the ratio

$$\frac{\text{initial pressure}}{\text{mean pressure}} = 5{\cdot}64$$

for unjacketed cylinder, and 5·36 for jacketed cylinder; giving a much greater condensation, in the unjacketed cylinder.

The same writer, for the *Journal*, says, that "there is no doubt that a higher degree of expansion is possible with a steam-jacketed cylinder." There lies economy.

I cannot see how admitting more steam, already on the point of condensation, can prevent other steam, with which it is brought into contact, from condensing, as all must expand together.

Steam, in the steam jacket, superheats the expanding steam in the cylinder, by the loss of its own heat, and thereby prevents condensation in the cylinder, to a great extent. It is not supposed to vaporize any that may lie upon the piston, except through the superheated steam in the cylinder.

Two questions arise in regard to steam jacketing. 1st.—Whether it is better to condense steam in the cylinder, thus assisting the condensation by expansion, and to expand the remaining low steam, or to condense steam in the jacket, and get the benefit arising from the use of high steam, together with the increased economy of a high grade of expansion. 2nd.—Whether the heat remaining in the water, into which the steam is converted, should go to the condenser to destroy the vacuum, and the water itself to load the pumps or go back to the boiler, for further use. I should say the latter, in each case. Although it is very right, and proper, for each one to judge for himself, some little weight should be given to the experience of Watt and other prominent men who have pronounced in favor of the steam jacket.

In the August number of 1869, page 11, we find the following. "A Cornish engine is now running which produces a lower duty than a double acting high pressure fly-wheel engine, used in the same works illustrating *defects in construction.*" This assertion is, without doubt, true, and the writer probably refers to the wonderful thing recently built for Spring Garden or some other Philadelphia Water Works, but which is really not a Cornish engine; or to that singular pair of twins in the West Philadelphia Water Works, that were designed to be Cornish engines, but are not, and which obstinately persisted, for a long time, in pumping water during the latter part of the stroke, only. I am glad to see that some one has the courage to compare them (unfavorably too) with the least economical type of rotative engine.

In the editorial note, September number, 1869, page 159, we find it stated that eighteen Cornish engines averaged a duty of only 50,100,000 pounds, lifted one foot high, by a consumption of 112 pounds of coal, or 447,321 foot pounds for one pound of coal. A horse-power means 33,000 pounds lifted one foot high, in a minute, or 1,980,000 pounds, lifted one foot high, in an hour. Dividing this by the number of pounds of coal consumed per horse-power per hour, we have the number of pounds, lifted one foot high, by the consumption of 1 pound of coal, and proceeding thus with the statistics already given, we have the following results, showing the comparative economy of the different engines.

At	1·9	pounds	per horse	power	…………	1,042,105	ft. lbs.	for 1 pound	of coal.
"	2·	"	"	"	…………	990,000	"	"	"
"	2·65	"	"	"	…………	747.169	"	"	"
"	3·	"	"	"	…………	660,000	"	"	"
"	3·125	"	"	"	…………	632,790	"	"	"
"	4·5	"	"	"	…………	440,000	"	"	"
"	3·75	"	"	"	…………	528,000	"	"	"
"	4·42	"	"	"	…………	447,321	"	"	"

The next to the last is the average of a number of Cornish engines, collected for this paper.

The last is the average of eighteen, given by the editor.

Fowey Consols 80″—exceptional—1·7 pounds per horse-power per hour, gives 1,160,714, for consumption of 1 pound of coal, or 130,000,000 for 112 pounds.

Rowans engine—exceptional—1·12 pounds per horse-power per hour, gives 1,767,857 for one pound of coal, or nearly 198,000,000 for 112 pounds.

After all that has been written about duty, in the January and August numbers of the *Journal*, for 1869, engineers, and other scientific men, will be as much astonished as I am, to find that most Cornish engines, of the present day, are very poor machines, and that several other classes of engines are superior; amongst them the much abused marine engine, which does the same amount of work with about one-half the coal consumed by the Cornish engine.

There is every reason to believe that if all attending circumstances were noted, and given due consideration, neither Rowan's engine, nor the Cornish engine, would have shown anything like the duty accredited to them. It is impossible to accept the belief that engineers of our day, in spite of their advances in scientific knowledge, are incapable of building a good pumping engine, and it is far more probable that these high duties are the results of very short, and imperfectly constructed, experiments. It must be remembered that there is a limit to the ability of steam to do work, even allowing it all that is claimed by Marriotte.

THE MOUNT WASHINGTON RAILWAY.

About a dozen years ago, Mr. Sylvester Marsh, then of Chicago, conceived the idea of constructing a railway up the rugged slopes of the White Mountains of New Hampshire, with a novel outfit of rolling stock, capable, as he believed, of transporting the throng of summer visitors to the summit of Mount Washington, 6000 feet above the sea level, on grades of 1 in 3. The boldness of the plan, emanating from a man who laid no claim to professional knowledge, caused it to be looked upon as visionary and impractible. For a long time Mr. Marsh vainly importuned engineers and capitalists to endorse his scheme. A small model of his track and machinery was on exhibition for years in the Merchants' Exchange of Boston without attracting any effective attention, and his application to the Legislature of New Hampshire for a charter was granted almost by default, nobody believing that it would ever be heard of again. But the projetor was persevering, and at length succeeded in enlisting the attention of parties interested in the various lines of railway over which the summer travel passed to and from the mountains. By their aid, in 1866, a short piece of experimental track was laid up the lower slope of the mountain, and an engine built to attempt the ascent. The experiment was successful. Capital was obtained to push it further, and in August, 1868, the line was opened for travel to a point within three-fourths of a mile of the summit, and at the commencement of the season of 1869 it was completed and put in use to the tip-top house, on the crown of the mountain.

At first the nervous travellers avoided the very airy looking conveyance, and only the bolder half tried the new and easy mode of ascent. A still smaller proportion attempted the descent, which was the most fearful looking of the two. But as no accident occurred—and it was demonstrated that ample provision had been made for the ordinary breakages and derangement of machinery or tracks—confidence was established, and the road obtained all the patronage that its equipment could accommodate. In illustration of its apparent safety, it may be stated that more than nine thousand tons of construction material have been transported over it, and great numbers of passengers, without accident or injury to property or person, the only individual ever injured being one of the workmen, who, having a careless habit of taking an easy way of getting down one of the steep inclines by placing a board on the centre track and sliding upon it, came to grief and a broken leg one day for want of a suitable brake on his machine.

The road bed of this extraordinary structure is mainly a timber trestle work, cut from the forest of spruce that covers the lower slopes of the mountain. The rails are of the ordinary strap pattern on longitudinal timbers, with a gauge of about 4 ft. In the middle of this track a third longitudinal timber is securely fastened, and surmounted with a heavy rack or ladder of wrought iron, into which steel pinions work from the engine and car, the motive power being a locomotive engine working through counter-shafts and pinions into this fixed rack. Iron pendants from the engine and car with flanges turning under the longitudinal timbers prevent the possibility of the train being lifted from the track by wind or other force, and by a combination of atmospheric brakes and brake straps on the pinion shafts the train can be stopped under all emergencies.

The engine is placed below the car, and retains its position both in the ascent and descent. It has an upright boiler and horizontal cylinder, with crank rod continuation of the piston, like an ordinary locomotive. The weight is about 7 tons.

The car body is of the ordinary American pattern, but about half the common size and capacity, mounted on four wheels only. The weight is about 4 tons, and the seats are placed as in a common American car, and so hung on stirrups as to retain their horizontal position under all circumstances, an advantage which is quite manifest when the incline brings one end of the car 30 feet higher than the other.

The time occupied in the ascent or descent of the three miles of railway is about one hour. The maximum grade is 1700 feet to the mile, and the average grade, from the elevated platform, where the road now starts at the foot of the mountain, is 1300 feet per mile.—*Engineering.*

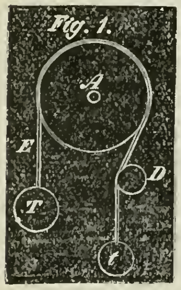
BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 385.)

We take the following series of interesting facts from "Practical Treatise on Mill Gearing." By Thomas Box, London: E. and F. N. Spon, 1869.

Driving Power of Belts.—Let A, in Fig. 1, be a pulley fixed so as to be incapable of turning, and T *t* weights suspended by a belt E, which passes round the pulley, and may be caused to embrace it more or less by a small guide-pulley D. Let now the weight T be increased until the friction of the belt is overcome, and it slips on the pulley, the weight T descending.



The ratio between T and *t* varies—

1st. With the coefficient of friction of the material of the belt E, sliding on the material of the pulley A. 2d. With the *proportion* which the arc of the pulley embraced, bears to the whole circumference of the pulley.

"It is independent of the breadth of the belt, *so long as* T *and* t *remain the same*, but inasmuch as T and t, or the strain on the belt, may increase with the breadth, this must not be understood to mean that a narrow belt will drive as much as a wide one; for other things remaining the same, the strain, and therefore the driving power, varies directly and simply as the breadth.

"The ratio between T and t is also independent of the *diameter* of the pulley, other things remaining the same; thus, for instance, a strap which slips on a pulley 1 foot in diameter, with a weight of 1 cwt. at one side, and 2 cwt. at the other, would do the same on a pulley 10 feet or any other diameter, the surfaces being similar.

"This appears contrary to our instinctive notions, but is quite correct, as I have proved by experiment. But this must not be understood to mean that a small pulley will carry as much power as a large one, for obviously, if both are set in motion, making the same number of revolutions per minute, the relative speeds of belt would be proportional to the diameters, and the power would vary in the same ratio.

"From Morin's experiments the coefficients of friction are as follows:—

·47 for leather belts in ordinary working order on wooden pulleys.
·28 " " " " " cast iron "
·38 " " soft and moist " " "
·50 for cords or ropes of hemp on wooden pulleys.

"It appears from Morin's experiments that with cast iron pulleys the driving power is the same whether they are turned or not, the adhesion of the belt to the polished surface generating as much friction as with a rough surface.

"If we take the case of a belt in ordinary working order on a cast iron pulley, the coefficient of which is ·28, and calculating for four cases in which the circumference is successively $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and wholly embraced, we find that while $t = 1$ in all cases, T becomes successively 1·553 — 2·41 — 3·77 and 5·81.

The following table is calculated in this way, and gives throughout the value of T when $t = 1$ for different kinds of surface of pulley and states of belt. Decimal parts of circumference of pulley are given instead of fractions named above.

"When a rope is used, and it is wound more than once round the drum, the frictional power is enormous; thus with a rough wooden pulley and a rope 2·5 times round it with $t = 1$, T is 2575·3.

TABLE showing *ratio* of strains on the belts of driving pulleys, Q = T — *t*.

Ratio of the arc embraced by the belt to the entire circumference.	*t*	New belts on Wooden Pulleys.		Belts in the ordinary state on				Soft belts on Cast Iron Pulleys.		Ropes on wooden drums.			
				Wooden Pulleys.		Cast Iron Pulleys.				Rough.		Polished.	
		T	Q	T	Q	T	Q	T	Q	T	Q	T	Q
·2	1	1.87	·87	1·80	·80	1·42	·42	1·61	·61	1·87	·87	1·51	·51
·3	1	2·57	1·57	2·43	1·43	1·69	·69	2·05	1·05	2·57	1·57	1·86	·86
·4	1	3·51	2·51	3·26	2·26	2·02	1·02	2·60	1·60	3·51	2·51	2·29	1·29
·5	1	4·81	3·81	4·38	3·38	2·41	1·41	3·30	2·30	4·81	3·81	2·82	1·82
·6	1	6·59	5·59	5·88	4·88	2·87	1·87	4·19	3·19	6·58	5·58	3·47	2·47
·7	1	9·00	8·00	7·90	6·90	3·43	2·43	5·32	4·32	9·01	8·01	4·27	3·27
·8	1	12·34	11·34	10 62	9·62	4·09	3·09	6·75	5·75	12·34	11·34	5·25	4·25
·9	1	16·90	15·90	14·27	13·27	4·87	3·87	8·57	7·57	16·90	15·90	6·46	5·46
1 0	1	23·14	22·14	19·16	18·16	5 81	4·81	10·89	9·89	23·90	22·90	7·95	6·95
1·5	1									111·31	110·31	22·42	21·42
2·0	1									535·47	534·47	63·23	62·23
2·5	1									2575·30	2574·30	178·52	177·52

"*Pulleys in Motion.*—We have so far considered the pulley as fixed; we will now apply the foregoing facts to the case of pulleys in motion. The mechanical conditions of a driving pulley, with half its circumference embraced by the belt are shown by Fig. 2, in which we have, as before, the pulley A and the weight T and *t* as in Fig. 1, where we found them to be respectively 1 and 2·41. But in this case, the pulley A being free to turn, the weights T and *t* being unequal, there would be no equilibrium without an additional weight at Q, and supposing the drum J to be the same diameter as the pulley A, it is self-evident that the sum of Q and *t* must be equal to T; therefore T — *t* = Q; or 2·41 — 1·0 = 1·41 = Q.

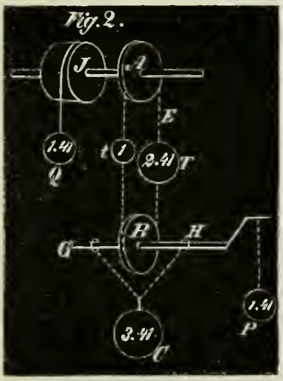


Fig. 2.

"The mechanical power transmitted by the belt, supposing Q to be raised by a rope coiled around the drum as a hoist or windlass is the *difference* between T and *t*, and Q might be increased indefinitely, if we could increase T and *t* indefinitely in the normal proportion; there is, however, a limit to which this can be done, namely, the cohesive strength of the strap by which the heaviest weight T is carried. Where leather is used we can obtain the requisite cohesive strength by increasing the width of the belt, or by making it a double or treble one and this width must in all cases be proportional to T, and not to *t* or to Q.

"In Fig 2 G may represent the engine shaft, H its crank, and P the power which is equal to Q. It will be observed that the weight C or pressure on the bearings due to the tension on the two straps, and also the maximum tension T is much greater than the power P or the weight Q

"If the weight Q had been 1·0, the maximum tension T would evidently have been $\frac{2{\cdot}41}{1{\cdot}41} = 1{\cdot}71$, and the minimum tension t have been $\frac{1{\cdot}0}{1{\cdot}41} = {\cdot}71$, and thus we obtain the strain as shown in Fig. 3; this is the most useful form in which the question can be put, as we thus obtain the proportional maximum strain or width of belt for a unit of power at P.

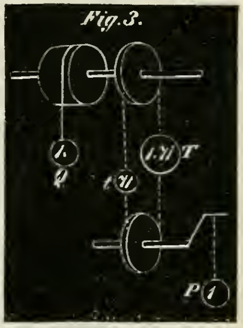


Fig.3.

"With a wooden pulley the friction of the surfaces is greater, and the strains for the weight Q are different. Here for $t=1$ we find by the table above that T is 4·38, and hence $Q = 4{\cdot}38 - 1 = 3{\cdot}38$. For Q or $P=1$ we should have $T = \frac{4{\cdot}38}{3{\cdot}38} = 1{\cdot}29$, and $t = \frac{1}{3{\cdot}38} = {\cdot}29$; so that with the same power P, a belt 1·29 inch wide, on a wooden pulley would do as well as one 1·71 inch wide on a cast iron one.

"In the case of a pulley of cast iron with $\frac{2}{10}$ths of the one embraced, the table shows that $T = 1{\cdot}42$, and t being 1 0, Q will be $1{\cdot}42 - 1 = {\cdot}42$. For $Q=1$ we have $T = \frac{1{\cdot}42}{{\cdot}42} = 3{\cdot}38$, and $t = \frac{1{\cdot}}{{\cdot}42} = 2{\cdot}38$.

"With a crossed belt on cast iron pulleys the arc embraced being $\frac{7}{10}$ths of the circumference, we have $T = 3{\cdot}43$, by table $T=1$, and $Q = 2{\cdot}43$; and hence with $Q=1$, we obtain $T = \frac{3{\cdot}43}{2{\cdot}43} = 1{\cdot}41$, and $t = \frac{1}{2{\cdot}43} = {\cdot}41$.

Comparing all the cases presented it will be seen that with the same engine power, the breadth of belt would be in the ratio 1·71, 1·29, 3·38 and 1·41.

THE CENTRAL PACIFIC R. R.

From the *American Churchman* we extract the following graphic description of this road and the engineering difficulties conquered in its construction:—

The courtesy of the officers of the Central Pacific—the California side of the railroad connection to Promontory in Utah—gave me, last evening, the pleasure of a ride on the engine *up* the Sierra and round Cape Horn, and to-day an opportunity, from the same point of observation, of enjoying the ride through the rock walls of Humboldt and Twelve Mile Canyon.

My thanks are due to Mr. Crocker and Superintendent Towne for the bit of pencilled paper by which I was enabled to enjoy one of the most delightful experiences of my life.

The real difficulty in the way of engineering, in connecting the two oceans, occurs on the western side. It is all plain sailing on the eastern till the road descends by a steep grade and through a pair of long tunnels into the Salt Lake Basin by Weber and Echo Canyons. The Level plains of Nebraska, and the high table land of the Laramie Plains, by which the road ascends and crosses the Rocky Mountains, at an altitude of eight thousand feet, offered no difficulty to the engineer. The trouble on the Union Pacific was from the Indians—the warlike Sioux and Cheyennes,—and from the fact of the great distance from supplies and material.

But on the western side, the engineering problem was the great one from the start.

Immediately after leaving Sacramento the ascent begins, and the problem was to ascend the Sierra Nevada range to a height of seven thousand feet within a distance of eighty miles.

There was no getting round the thing. The mountains stood there barring the way eastward. *They* would not get out of the way for a railroad, and the "passes," by which travelers in the old time surmounted the obstacle, are all from five to eight thousand feet at their height above the sea level.

It was, indeed, the common talk in California that it was *impossible* to carry a railroad up the western face of the Sierra. Even good engineers considered the undertaking preposterous.

It is easy enough to mount it from *the east*, for the high table land of the "great desert" comes up to its eastern side from four thousand to five thousand feet. In fact the Sierra Nevada is the

Western face of an embankment,—the embankment being half a continent, and this, the guttered and storm-washed front of it towards the Pacific.

The point was to get up this rocky face to the table land it bounded, and to do that in a very short space, for the continent breaks off short and comes down sheer.

But California energy, using ten thousand patient Chinamen, solved the problem, and took the track up and over, along the mountain side, through deep and long tunnels across rifted chasms in the rocks, over headlong torrents and by the dizzy edges of abysses thousands of feet down,—and "around Cape Horn."

But even when the work was done, the snow avalanche or the earth slide from the mountain round whose side half up, the iron path winds twisting upward, might sweep the work away, or overwhelm the track and make it useless for weeks or months.

There was a remedy also for this in the skill and determination of the men who did this work. They just roofed in their road for fifty miles!

They took the giant stems of the pines and braced them against the mountain side, framing them and inter-lacing them beam with beam. They sloped the roof sustained by massive timbers, and stayed by braces laid into the rock, and covered with heavy plank, up against the precipice, so that descending earth or snow would be shot clean over the safely housed track into the pine tops below, and so they run their trains in security under cover, and have conquered the snow in its own domain.

There is one drawback. These "snow sheds" shut out forty odd miles of the most magnificent scenery on the whole trip—notably Donner Lake, and the deep valley enclosing it, which lies straight down below the passing trains.

It was up this slope I traveled yesterday afternoon and evening. It takes two locomotives to persuade the trains to ascend. I found a place just after leaving Sacramento, on the foremost, and had a mountain ride, which I think must be unequalled considering the mountains and the horse.

First there was the Sacramento valley—oak opening all, which, to most of your readers, needs no description. Only the oaks are of a species not seen in Michigan or Wisconsin. California is rich in oaks, and these scattered about as thickly as apple trees in an old orchard, are the live oak, small leaved evergreen.

Then came the "foot hills" and a gradual change in the wood-growth. The Manzanilla wood with its shining stem and dark green glistening leaf mingled with the oaks, and the buckeye which in California is a many-stemmed bush, springing from a common root, hung heavy with its pear shaped fruit, filling up the space beneath the taller oaks and the nut pines.

Finally we came into the realm of the *coniferæ* and the tall stems sprang up smooth, branchless and tapering, rearing their green coronals to the sky.

We were going up the mountains! In a valley on one hand lay a mining village—the most beautiful villages in the State are these mining villages now. Down the mountain side, on the other, ran the water, led in sluices like a mill race, around a point here and a bend there, and across a gorge yonder—the water to be used under the mighty power its descent gives it to tear the hill side down and wash the rocks to pieces in "hydraulic mining,"—mining that is which consists in discharging a stream of water, with a head of a few hundred feet full in the face of a hill side till it is knocked into bits!—bits which contain gold, of course, or are supposed to.

But these too are left as we go clanking on through pitch dark tunnels and over trestle works that look like spider's webs and along the maze of dingy precipices, the engines coughing and straining in the tug up the steepest grade yet ventured by any engineer.

The day died out before we reached the summit, but died into a cloudless moonlight, a moonlight so brilliant, so silvery white in the flood of light it poured across land and sky, that one sent no regrets after the sunset.

Moonlight in the mountains, and such a moonlight is something to be remembered for life. I lost all sense of the poor every-day world, forgot so vulgar a thing as a railway car, even the clank of the engine seemed to come softened as from far away, and I was sailing over pine-clad mountains, silvery white, in an air of balm and fragrance, and—in fact, I think was *about half asleep* when my friend, the engineer, plucked my sleeve,—we were doubling Cape Horn!

Round the jutting mountain wall, so called from its bold advance into the valley, and its precipitous face, the road winds like a ribbon. No human foot had ever trodden this height as far as man may judge, till the first "hand" was lowered down to lash himself to a tree and begin, with pick and spade and crow, to cut a shelf along the dizzy height! Not even an Indian trail had ever passed where the long train was passing now. The foot-sure savage had never ventured here. Three thousand feet sheer down lay the valley, in the moonlight, like a lake, the mist slowly rising and swaying, silvered by the descending light. The feathery tops of the rock-anchored pines rose out of the mist far below. Across the valley the other mountain face frowned darkly, shaggy with bristling pines from base to summit.

That was one side.

On the other rose the almost perpendicular wall of the mountain, round which we were rushing on a shelf cut into the rock wide enough for the rails, of course—what need of anything more, when they are treble spiked, and the rolling stock of the best, and the engineer the safest man to be found?

If we went off? If a broken rail should be ahead, if a rock should have rolled down beyond the curve yonder? Well, I suspect it would not make much difference, in that case, whether one was on the engine or in a car yonder. It would amount to the same thing, I think, when we all reached the valley together.

But there has never been an accident, and it is just such places as this that are most carefully guarded, and where all prudence, and forethought, and skill, are engaged to be active.

I do not know that I have been able to give you half an idea of the magnitude of this undertaking, which has annihilated these weary desert spaces and brought East and West together. If I have said much about it, it is because, after all, looking at it as I have, it seems to me the railroad across the continent, the double iron bands that tie Omaha and Sacramento each together, over the mountains, across vast deserts where human life finds nothing to sustain it, through the territories of tribes too, a few years ago a terror to the whole border—it seems to me the *railroad* is really the most wonderful thing one sees, after all.

Yellow the Brightest Color.—Experiments made to ascertain what colors are most quickly and easily perceived by the eye seem to show that bright yellow is the color most easily distinguished, and is therefore suggested for railway signals.

ON THE LOSSES OF PROPELLING POWER IN THE PADDLE-WHEEL.

By R. H. Thurston, First Assistant Engineer, Assist. Prof. Nat. Phil., U. S. N.
(Member of the Institute.)

In a marine steam engine of good design and in good order, about seven *per centum* of the indicated horse-power may be expected to be consumed in the moving of the parts of the machinery itself, the remaining ninety-three *per centum* being applied to the propelling instrument.

Where the radial paddle-wheel is used, a considerable part of the work done by the wheel is expended uselessly in forcing the water downward, or in lifting it; and of that power which finally acts horizontally, a part is unavoidably lost in setting in motion the water upon which the wheel acts. Thus the power exerted by the *engines* is considerably greater than that exerted by the *ship* in resisting motion.

To ascertain the amount of these losses, when the vessel is at rest, as on the instant of starting the engines, the first of these losses, that from oblique action, is easily calculated thus:—

Measure the length of the immersed arc described by the centre of pressure of the floats, and the length of its chord. The ratio of the squares of these quantities will give the ratio of total power exerted to power expended horizontally by the wheel.

When the vessel moves ahead, the conditions of the problem are at once greatly changed.

The floats, then, instead of moving in a circle through the water, describe the curve shown in Fig. 1.

They then move through the water obliquely, and with velocities varying every instant.

This forward movement gives, to some extent, a "feathering" action to the floats, and with a properly proportioned wheel, the loss from oblique action becomes very greatly diminished.

The path of the float R *c* being in the direction *c d* instead of the direction *a b*, the principal portion of the work is done in the lower portion of the path of the float, where there is less oblique action.

Noticing the positions assumed by the floats at different points *c*, *s*, *l*, &c., and the direction of their motion, it becomes evident, also, that the amount of "dip" influences the amount of loss from oblique action very greatly when the vessel moves ahead, as well as in the previous case, and the most economical wheel will be that in which the sum of the losses from dip and slip are reduced to the greatest extent.

To ascertain the amount of loss of power in oblique action:—

See Fig. 2.—Let $V =$ velocity of paddle-float at centre of pressure.

$v =$ velocity of vessel.

$a =$ angle included between an arm C A and horizontal line through C.

$\beta =$ any other angle as B C v.

$\mu = \frac{v}{V}$. $r =$ radius.

Jr of Franklin Inst Vol. LVIX *Loss of Propelling power in the Paddle Wheel* *Plate I.*

Fig. 1.

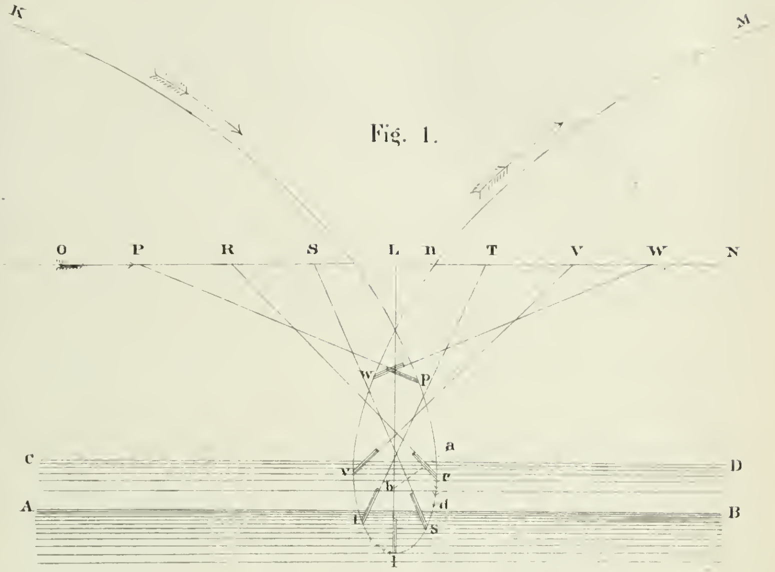
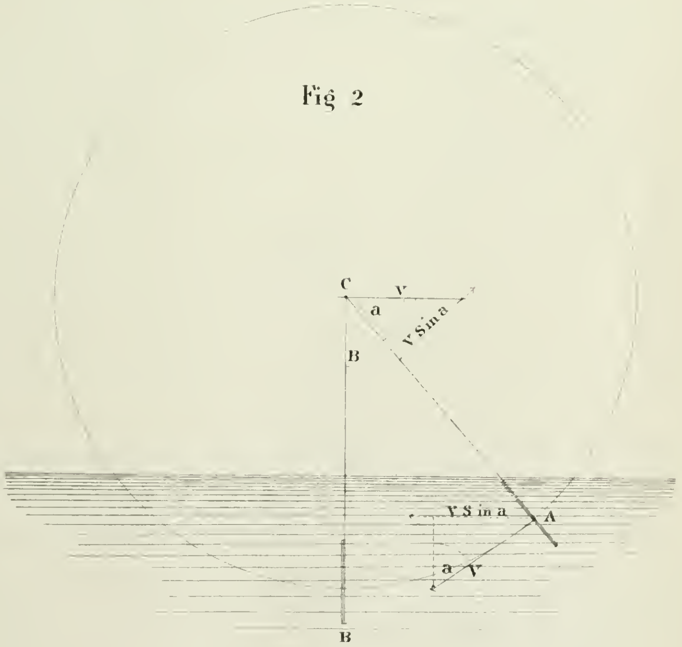


Fig 2



The tangential velocity of the centre of pressure of any float A C will be $(\mathrm{V} - v \sin. \alpha) = \mathrm{V}\,(1 - \mu \sin. \alpha)$, and the horizontal velocity through the water will be $(\mathrm{V} \sin. \alpha - v) = \mathrm{V}\,(\sin. \alpha - \mu)$.

The normal pressure on a unit of area of the float will be measured by the square of its velocity in the direction of that pressure, or $\mathrm{V}^2\,(1 - \mu \sin \alpha)^2$, and the total work done by the engine in turning the float through any arc A B, will be—

$$r\,\mathrm{V}^2 \int_{\alpha}^{\beta} (1 - \mu \sin. \alpha)^2\, d\alpha, \quad . \quad . \quad . \quad . \quad (1.)$$

The horizontal component of the pressure on the float, which only is useful in propelling the ship, will be—

$$\mathrm{V}^2\,(1 - \mu \sin. \alpha)^2 \sin. \alpha.$$

While the float is moving through the arc $r\,d\alpha$ in the time $dt = \frac{r\,d\alpha}{\mathrm{V}}$, this horizontal resistance will be met through a space $\mathrm{V}\,(\sin. \alpha - \mu)\,dt = r\,d\alpha\,(\sin. \alpha - \mu)$, and the power expended horizontally upon the water while the wheel moves through any arc A B will, therefore, be expressed by—

$$r\,\mathrm{V}^2 \int_{\alpha}^{\beta} (1 - \mu \sin. \alpha)^2 \sin. \alpha\,(\sin. \alpha - \mu)\, d\alpha, \quad . \quad (2.)$$

But while this amount of work is expended upon the water, the wheel must, in consequence of the slip, do a greater amount of work in a proportion varying at each point with the slip, and the total horizontal work of the wheel will be obtained by multiplying the expression (2) by the factor $\frac{\mathrm{V}}{\mathrm{V}\,(1 - \mu \sin. \alpha)}$.

The total amount of work done in this direction, then, while passing through the arc A B, will be, including slip,—

$$r\,\mathrm{V}^2 \int_{\alpha}^{\beta} (1 - \mu \sin. \alpha)\,(\sin. \alpha - \mu) \sin. \alpha\, d\alpha, \quad . \quad (3)$$

The ratio of (3) to (1) will be the ratio of gross horizontal work to the total work done on the wheel.

Integrating between limits, this ratio becomes—

$$\frac{(3.)}{(1.)} = \frac{\frac{\mu^2 + 1}{2}(\beta - \alpha) + 2\mu(\cos. \beta - \cos. \alpha) - \frac{\mu}{3}(\cos.^3 \beta - \cos.^3 \alpha) - \frac{\mu^2 + 1}{4}(\sin. 2\beta - \sin. 2\alpha)}{\frac{\mu^2 + 2}{2}(\beta - \alpha) + 2\mu(\cos. \beta - \cos. \alpha) - \frac{\mu^2}{4}(\sin. 2\beta - \sin. 2\alpha)}$$

In this equation, making α the angle of entrance of the mean centre of pressure of the float and calling $\beta = 90°$, $\frac{v}{\mathrm{V}}$ being known, the loss of power in *any* wheel by oblique action may be obtained by subtracting the ratio resulting from our final equation from unity.

The following are data assumed and results obtained as above:

First case.	Second case.	Third case.	Fourth case.
$a = 60° = \frac{\pi}{3} = 1{\cdot}047$	$a = 42° = \frac{7}{30}\pi$	$a = 30° = \frac{\pi}{6}$	$a = 0° = o.$
$\beta = 90° = \frac{\pi}{2} = 1{\cdot}570$	$\beta = 90° = \frac{\pi}{2}$	$\beta = 90° = \frac{\pi}{2}$	$\beta = 90° = \frac{\pi}{2}$
$\frac{v}{V} = \frac{3}{4}.$	$\frac{v}{V} = \frac{3}{4}$	$\frac{v}{V} = \frac{3}{4}$	$\frac{v}{V} = \frac{3}{4}$
Dip. $= \frac{3}{20}$ radius.	Dip. $= \frac{1}{3}$ radius.	Dip. $= \frac{1}{2}$ radius.	Dip. = to centre.
Efficiency = ·949.	Efficiency = ·907.	Effic. = ·83.	Effic. = ·70.
Loss by oblique action = ·051.	Loss = ·093.	Loss = ·17.	Loss = ·30.

The first case corresponds to that of light river steamboats, the second to that of ocean steamers, while the third is an exaggerated, though not remarkably rare case. The fourth case is given simply in illustration of the use of the formula; it, of course, is unknown in practice.

Here the efficiency and loss are expressed, not in fractions of total indicated horse-power, but of the power applied to the wheel, and, referred to I. H. P., those losses would be ·047, ·086, ·158 and ·28, respectively.

If it is required to find the loss of power by oblique action and slip combined, and thus to ascertain if the designer of the hull has fulfilled his guarantees, the net power expended in simply overcoming the resistance of the ship must be obtained. The amount of horizontal expenditure of power just obtained must, in this case, be reduced by multiplying by the ratio $\frac{V - v}{V}$, or it may be taken from (2).

In the examples given above, the slip is assumed to be known, and in each case is taken at 25 *per cent.*, and this net power usefully expended is found, after making this reduction, to be ·714, ·685, ·631 and ·52 of total I. H. P.

In the fourth case, the *slip* would actually be very much greater than is assumed above, and the efficiency would probably fall below twenty per centum of the indicated horse-power.

Our results agree very closely with those deduced from experiment; and the method by which they are obtained has, we believe, never before been published.

U. S. Naval Academy, Annapolis, Md., Dec., 1866.

Mechanics, Physics, and Chemistry.

THE TRANSATLANTIC LONGITUDE.

By Dr. B. A. Gould.

From the Report on the above subject, made by Dr. Gould to the Superintendent of the U. S. Coast Survey which has just been published in the Smithsonian Contributions to Knowledge, we make the following extracts and abbreviations which will be of interest to many of our readers into whose hands the entire and extensive work is not likely to come, or who might lack time and courage to attack so formidable a *piece de resistance* as a quarto of some 125 pages.

1.—*Origin of the Coast Survey Expedition.*

The determination of longitudes by means of the electro-magnetic telegraph, was, as is well known, first practised by the U. S. Coast Survey ; and the methods by which it attained its full development were here in use for several years before they began to be employed elsewhere. From the year 1849 until the beginning of the late war, early in 1861, they were unremittingly prosecuted. At that time, 24 independent determinations had been made, no pains had been spared for the attainment of all possible precision; and the series of telegraphic longitudes extended from the northeastern boundary to New Orleans, covering 2½ hours of longitude and 15° of latitude within our own territory, as well as some portions of the British provinces. Upon the completion of the Pacific Telegraph, arrangements were made* for extending the connection to San Francisco; but these were reluctantly deferred in consequence of the condition of the country.

For longitudes reckoned from any trans-Atlantic zero, much coarser methods only have hitherto been available; and the uncertainty of the determinations has been twenty or thirty times greater than that between any of the points which form the series of American determinations, and very much larger than that between any points referred to these fundamental ones, by the geodetic operations of the Survey.

The Atlantic cable promised at last to afford an opportunity of connecting the American with the European longitudes, and thus of reducing the two independent series of determinations into what should practically be but one. The large views of the late honored head of the Coast Survey, Prof. Bache, led him to take immediate steps for the attainment of this end; and upon the first organization of the Atlantic Telegraph Company, to the assistance of which he gave his hearty and effective support, he obtained* from the officers of this and of the Newfoundland companies their ready promise of all needful facilities for determining the relative longitude of their terminal stations.

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*Coast Survey Report, 1861, p. 2.

Immediately upon the landing of the cable at Trinity Bay, Mr. Hilgard was dispatched to this remote spot, in order to decide from personal inspection whether the communication were sufficiently good to permit of satisfactory longitude signals, without delay; but his report was necessarily adverse.

Upon the organization of the telegraphic cable-expedition of 1865, Mr. Hilgard, who, during Prof. Bache's illness was acting in his behalf, obtained anew from the respective companies permission for our use of the cable, if successfully laid: and the Hon. Secretary of the Treasury anthorized the necessary outlays. Mr. L. F. Pourtales repaired to Heart's Content, and there awaited the arrival of the Great Eastern, in order to notify me without delay of the character and availability of the signals, should the cable be successfully laid; but the rupture of the cable in mid-ocean made his expedition unavailing.

The same preliminary steps were again taken in 1866, Mr. G. W. Dean awaiting the arrival of the Great Eastern at Heart's Content. The expedition of this year was happily successful, and Mr. Dean reported by telegraph that the sharpness of the signals was all that could be desired. Measures were at once taken for organizing the parties. Mr. Dean returned only a few hours too late to present his report while we were attending the session of the National Academy of Sciences at Northampton; but he found Mr. Hilgard and myself at the meeting of the American Association in Buffalo, where all the details for the expedition were arranged without delay, and the needful directions for preparation of instruments and observers given by Mr. Hilgard.

The large interval between the meridians of the two extremities of the cable precluded the employment of the method of star-signals, for many reasons. This method requires a more protracted occupation of the cable than it seemed right or reasonable to solicit; the climate of Newfoundland, according to the best information received, is too uncertain and variable to warrant reliance upon the continuance of a clear sky for three hours, while unless they should promise favorably it would be unwise to employ the cable for transmitting observations from Valencia, which would be useless unless combined with subsequent observations of the same stars from Heart's Content. Moreover, for a longitude so great as that to be measured, the special advantages of the method of star signals chiefly disappear; the clock-rates becoming matters of serious importance, and entailing errors of the same order of magnitude as those of the absolute time-determination, while the wide separation of the observers precludes that thorough elimination and control of personal equation which is feasible when the longitude observations are restricted to zenithal stars, and the observers can easily exchange positions and frequently meet at one or the other station.

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*Ibid. 1858, pp. 33, 34, 43; 1859, p. 6.

There was also ground for confidence that the catalogue of standard stars to be employed for determining time was so well freed from systematic errors, that the difference of half a quadrant in the meridians would introduce no error depending on the right-ascensions, no matter at what hour the comparisons might be made —a confidence which the event has fully justified.

[A description here follows of the various previous determinations of longitude by the several methods following,

1st. From Eclipses and Occultations by which values have been obtained of the difference between Greenwich and Washington, ranging between 5h. 8m. 11·14s. and 5h. 8m. 13·13s

2nd. From Moon Culminations varying between 5h. 8m. 9·3s. and 5h. 8m. 11·6±4s.

3rd. From Chronometers in which the results of different expeditions varied from 5h. 8m. 11·14s. to 5h. 8m. 13·43±0·19s.]

All of these values require to be increased by 0·06s. to conform to the new telegraphic determination by the Astronomer Royal of the longitude between Liverpool and Greenwich.

The discordance of results which individually would have appeared entitled to full reliance is thus seen to exceed four seconds; the most recent determinations, and those which would be most relied upon, being among the most discordant. No amount of labor, effort or expense had been spared by the Coast Survey for its chronometric expeditions, inasmuch as the most accurate possible determination of the trans-Atlantic longitude was specially required* by law; and the thorough accuracy of Prof. Newcomb's investigations is well known to astronomers. Yet the result of the latest chronometric expedition differs from that deduced by Newcomb,—from moon-culminations observed at the Washington Observatory since its regeneration, compared with those observed at Greenwich,—by more than three and a half seconds of time.

The value employed by the Coast Survey from 1852 to 1859 was 5h. 8m. 11·2s.; since 1859 it has been 5h. 8m. 11·8s.

III.—*History of the Expedition.*

The building erected in Calais, Maine, and occupied as a longitude-station in 1857, was still in existence, though much dilapidated, the stone piers being undisturbed. Mr. George Davidson, Assistant in the Coast Survey, was to take charge of this station, with Mr. S. C. Chandler, Jr., as aid. Mr. Dean was assigned to the station at Heart's Content, with the assistance of Mr. Edward Goodfellow; while I was to occupy the Valencia station, Mr. A. T. Mosman accompanying. Each station required a small transit-instrument, a chronograph, and an astronomical clock. * * * *

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*Monthly Notices R. Astr. Soc., VIII, 186; Mem. R. Astr. Soc, XVII. 52.

Messrs. Davidson and Dean left Boston for Halifax in the steamer of Sept. 5, to make an examination of the condition of the telegraph line, and a week later Messrs. Goodfellow, Mosman and myself sailed in the Cunard steamship Asia, bound for Liverpool, *via* Halifax and Queenstown, taking the instruments for Newfoundland and Ireland. But a short time before our departure the welcome tidings had arrived of the recovery, in mid-ocean, of the lost cable of 1865, and of the successful continuation of this second line to Newfoundland.

To the courtesy and interest of the officers of the Cunard Company we were indebted, from the beginning to the end of our expedition, for many favors and much assistance. The cordial and effective aid of Captain J. P. Anderson of H. B. M. mail steamer Africa, then temporarily in command of the Asia, was of peculiar value, and calls for the sincerest acknowledgements. I may also mention here our obligations to Mr. Grierson, agent of the Cunard steamship at Queenstown, who, both at the debarkation and reshipment of the instruments, assisted us in the most effective manner.

[An account is then given of the journey to, and preliminary adjustments at, the station finally selected at Foilhommerum Bay.]

The peculiarily unastronomical sky of Valencia delayed adjustments for a while; but one or two glimpses of the sun at noon enabled us to establish our meridian, and, on the 14th October, at 3 A. M., we obtained transits of a few stars. At that time the observers in Newfoundland had seen neither sun, moon nor stars: and I am inclined to believe that, excepting the short period when sharp frosts prevail there, the climate of Newfoundland is nearly as unfavorable for astronomical purposes as that of Valencia itself. As regards the Valencia climate, I was informed, on our arrival, that it had rained every day without exception, for eight weeks. During the seven weeks of our sojourn, there were but four days on which no rain fell; and there was but one really clear night during the period while the instruments were in position. The observations were, in general, made during the intervals of showers; and it was an event of frequent occurrence for the observer to be disturbed by a copious fall of rain while actually engaged in noting the transit of a star.

The method of telegraphing through the Atlantic cable is based upon the ingenious device of Prof. Thomson, in applying to a delicate galvanometer the principle of reflection used by Gauss for heavy magnets. A small mirror, to the back of which is attached a permanent magnet, the joint weight of the two being from five to six centigrams, is held by means of a single fibre above and below, in the centre of a coil of fine wire, which forms part of the galvanic circuit; and its position and sensitiveness are regulated by movable bar-magnets placed in the immediate vicinity. Upon the mirror is thrown a beam of light through a slit in front of a bright kerosene lamp, and the deflections of the needle are noted by the movements of the reflected beam, which is received upon a strip of white paper. The exquisite delicacy of this galvanometer as well as the electrical excellence of the telegraph cables, may readily be appreciated after the beautiful experiment in which the electricians at Valencia and Newfoundland conversed with each other on a circuit not far from 700 myriameters (4320 statue miles) in length, formed of the two cables joined at the ends, using a battery composed of a percussion gun-cap, a morsel of zinc, and a drop of acidulated water.

The absence of any means for the automatic registration of signals received, presented, of course, a very serious obstacle in the way of an accurate longitude determination, inasmuch as the loss of time in noting the signals was not only very considerable, but quite uncertain; but the programme of operations which I had prepared before leaving home was based upon the assumption that the use of self-registering electro-magnetic signals would not be acceptable to the Telegraph Company. All objections to these were, however, waived in our favor by Mr. Latimer Clark in the most cordial manner, and considerable time was expended on two evenings in endeavoring to obtain satisfactory signals which would be self-registering. Unfortunately, these efforts were unsuccessful. The cable could not be discharged with sufficient rapidity for the purpose when the charge was sufficiently strong to actuate our most sensitive electro-magnet. A permanent deflection only was observed at Newfoundland, while the Valencia clock was breaking the circuit during an eighth part of every second; nor did any modification in the character of the battery render these interruptions of continuity perceptible at the other extremity of the cable.

I had previously designed availing myself of an elegant suggestion of Dr. Gibbs, by which the heat from the lamp should be concentrated and reflected, together with the light, by the mirror-galvanometer; being then received on a very delicate thermo-electric pile, which should thus record upon the chronograph the time of the signals. But too little time was available for the purpose, and although Mr. Farmer, whom I had requested to prepared some apparatus based on this principle, made sufficient progress with his experiments to show the practicability of the suggestion, he was obliged to abandon all hopes of constructing any satisfactory instrument in season to be available for our purposes.

Thus it became necessary to fall back upon the original programme which had been prepared before leaving Boston, and furnished to Messrs. Dean and Davidson. (A programme of the order of signals here follows, which we omit).

On the 24th October, longitude signals were exchanged with Newfoundland for the first time. Between that date and November 20, four more opportunities had been found, and the entire series of experiments for determining the velocity of signals under different circumstances had been satisfactorily tried, as well as some others which I found practicable at Valencia, although not provided for in the programme.

Meanwhile the Astronomer Royal, who had, with his usual kinddess, acceded to my request for a telegraphic connection between our station-point and Greenwich, and assumed all the labor and embarrassment of the necessary arrangements, had carried out the series of exchanges with Foilhommerum, an undertaking attended with no little inconvenience and vexation from the various difficulties attending land lines, especially when a submarine cable of the length of that across the Irish Channel forms a part of the circuit. After many fruitless attempts, clock-signals were exchanged on three nights, upon two of which the time was well determined at both places.

Upon the 20th November, the weather at Heart's Content as well as at Valencia, was extremely unpromising; no communication had yet been obtained between that station and Calais, and it seemed best, on all accounts, to bring our cable signals also to an end. After visiting Greenwich to offer such aid in the reduction of the longitude exchanges with that Observatory as might be acceptable to the Astronomer Royal, Mr. Mosman reached home on the 22d December, and I followed four weeks later.

The personal error, with other loss of time in observing signals, has happily proved more constant and more measureable than I had ventured to anticipate. No matter how great the interval, the resultant longitude will only be affected by one-half the difference of the values for the two observers; while the average value for the two observers could be merged with the time of transmission for the signals. It is not the least satisfactory of our results that this interval proved capable of measurement with a degree of accuracy which leaves no ground for apprehension that it has appreciably affected our value for the longitude, and which enables us to infer the velocity of transmission within restricted limits of probable error. * * * *

IV.—*Observations at Valencia.*

Here the Krille clock and Transit-instrument No. 4 were employed. I had supposed all precautions taken to insure that the instruments should be in good order; but, owing probably in part to the haste with which the expedition was organized in view of the approach of winter, this was not the case, and the want of proper condition of both these instruments, as well as of the minor telegraphic apparatus, much augmented the unavoidably serious difficulties of the enterprise.

Observations were obtained on fifteen nights during our sojourn at Valencia, on no one of which the sky was unclouded. On only two of the five nights on which longitudinal signals were exchanged with Newfoundland was it possible to obtain observations after the exchange, and this was possible, too, on only one of the three nights when signals were successfully exchanged with Greenwich. Observations of circumpolar stars for the special purpose of determining the intervals of the transit threads, were out of the question. Indeed, there was but one instance when a transit of any star north of 60° declination was observed over all twenty-five threads. In those rare instances when this would have been possible, the stars were needed for determining the error of collimation. * * *

With these few explanations, and the added remark that the observations for time were almost without exception obtained with extreme difficulty in the intervals of clouds and rain in one of the most unfavorable climates of the globe for an astronomer, I give the crude observations, and their reduction for the groups immediately preceding and following each series of longitude signals, omitting the others generally as needless. The notation and methods of observation and reduction are those prepared by me for the longitude work of the Coast Survey some fifteen years ago, and are described in detail by Mr. Dean in the appendix to the Coast Survey Report for 1856. The conditional equations for clock correction and azimuth are solved by least squares. after correcting for level-error and clock rate; the normal equations and resultant values being appended to each group. As already stated, my own observations have been referred to Mr. Mosman in every case, by substracting 0·08s. from the observed times.

[Here follows in the report an extensive series of tables with their discussion ending in the determination of longitude between Greenwich and Washington to be 5h. 8m. 12·39s. In the discussion of the observations a very interesting investigation is made of personal error in noting signals, as follows:—]

IX.—*Personal Error in Noting Signals.*

Since the signals sent through the telegraphic cable were recorded upon the chronograph automatically at the transmitting station, but at the receiving station, through the mediation of an observer who noted the deflection of the light spot from the galvanometer, by sending a second telegraphic signal to his own chronograph, it will be seen that the interval x, which elapses between the giving of a signal at one station and its chronographic record at the other, may be conveniently divided into four different parts, viz., the time requisite—

1. For the signal to arrive at the other station.
2. For the magnet of the galvanometer to be moved through an arc sufficient to be readily perceived.
3. For the observer to take cognizance of the deflection, and give his signal upon the break-circuit key.
4. For this observation-signal to be recorded upon the chronograph.

Each of these four parts comprises the time, appreciable or otherwise, consumed in more than one distinct process; yet this division suffices for all our purposes. If these several intervals be practically equal at the two stations, they become absolutely eliminated in our determination of the longitude. If they be unequal, the resultant longitude will require an increase by one-half the excess of their sum for westward signals. In either case only their total sum at the two stations is determined by the operations for longitude.

If we assume that the time lost upon the chronograph circuit is the same at each station, the last of the above-mentioned intervals becomes eliminoted by the comparison of the two records. The second and third depend upon the galvanometer and observer at the receiving station, and are not easily to be separated from each other in any determination of their amount; but if their sum can be measured, this, subtracted from our quantity x, will afford a trustworthy determination of the velocity with which the signals are actually transmitted through the telegraphic circuit.

This sum of the delays dependent on the galvanometer and the observer, I have called "the personal error of noting;" and the attempts to measure its amount have been so successful, and have manifested such an unexpected constancy in its value for different persons, at different times, and at both stations, that the results obtained for the velocity of transmission of our signals seem entitled to a high degree of confidence.

By observing a series of signals similar to those exchanged for longitude, and so arranged that both the original signal and the observation of the consequent deflection shall be recorded on the same chronograph, the desired measure may be obtained. Experiment showed at once that the interval thus determined was altogether too large for any inconvenience to arise from the use of a single recording pen. The obstacle first encountered arose from the circumstance that the minimum battery force requisite for the electro-magnet of the chronograph pen was about seventy-five times greater than the maximum which could be safely employed for the galvanometer signals. To obviate this difficulty, a battery of two Minotti cells being employed, the circuit was divided at the galvanometer into two branches—one, of fine German-silver wire, passing to the galvanometer and thence again to the main circuit, while the other branch was made to pass through the break-circuit key by means of which the deflections were noted. The resistances of these two branches were so adjusted that they were in the ratio of 1 to 100, by which device each signal at the observatory was sharply indicated on the galvanometer, without too great violence; and by a slight adjustment of the movable permanent magnets, it was always possible to render these deflections similar in amount to those received from Newfoundland. It was, of course, necessary to include the clock in the galvanic circuit, in order to obtain a time scale; but the interruption and restoration of the circuit at each oscillation of the pendulum caused a vibration in the galvanometer needle, which was not quieted for more than half a second, and then only to be renewed immediately. To render all the circumstance of the experiment as similar to those of the longitude-signals, as the nature of the case permitted, as well as to avoid any tendency to mechanical rhythm in the act of noting the signals (a source of inaccuracy which every observer by the chronographic method must have recognized whenever the beats of his clock have been audible or visible during the process of observation), it was necessary to dispense with the clock while the measures were actually in process.

The observations were therefore arranged as follows:—After the clock had been included in the circuit for some minutes, recording its beats upon the chronograph in the observatory, and manifesting them likewise upon the galvanometer in the telegraph office, the assistant in the observatory excluded the clock from the circuit by means of a plug-switch, thus stopping all record of time upon the chronograph sheet, although the pen continued to trace a straight line, and stopping likewise the pulsations of the galvanometer needle, by which indication the observer was warned that the signals were about to begin. He then gave a set of ten signals on one of the observing keys, at the same intervals, roughly, as those exchanged for longitude—namely, four sharp, quick taps upon the key, about five seconds apart; then, after ten seconds, three more; and, after another ten seconds, yet three more. At the close of this set of signals, he restored the clock to the circuit by removing the plug from the switch, and the graduation of the time-scale recommenced as before, after an intermission of scarcely a minute; so that the time of each signal could be read off by means of the second marks of the preceding and following minutes with an accuracy scarcely, if at all, inferior to that attainable when the time-record is simultaneously in progress. The chronographic records of the signals thus given are about 0·04 seconds long.

The observer is meanwhile at the galvanometer in the other building, out of sight and hearing of the assistant, and notes the moments of deflection of the light-spot by a tap upon the break-circuit key which he holds in his hand, taking care to conform in all respects to his habitudes while observing longitude-signals. The intervals between the chronographic records of the original signals and his observations of the same, then furnish a measure of the "personal error of noting" as already defined; and show the lapse of time corresponding to all the various delays of which our x is composed, except the actual time of transmission through the cable; unless the adjustments of the two chronographic or local circuits are so diverse that the loss of time which they entail cannot be regarded as equal for the two instruments. This is not the case, since repeated examination has shown that the difference is not measurable. The exclusive employment of signals given by interrupting the galvanic circuit, and of a pen which is not removed from the paper during the whole period, renders the measurement of armature time very easy, and eliminates it from ordinary observations.

[A series of obsevations were then made giving as a mean error of the mean, not the "probable errors," which would have been three times as great a series of results which for Dr. Gould give the final value 0·253 ± 0·006.] A series by Mr. Mosman gave 0·275 ± 0·014, and one by Mr. George, of the telegraphic staff, who had had no other previous experience in observing, gave 0·296 ± 0·017. From another series by Dr. Gould as the mean value 0·289 ± 0·005, Mr. Mosman's error from four determinations being—

0·322 ± 0·027
0·296 ± 0·031
0·303 ± 0·016
0·297 ± 0·013
and Mr. George's 0·309 ± 0·022

The galvanometer was evidently somewhat less sensitively adjusted than on the previous occasion, as was indeed known independently of the signals, since it had been undergoing some repairs; yet the average excess was but three and a half hundredths of a second.

The Kessels clock, at Heart's Content, was provided with two signal giving attachments, one being the ordinary arrangement for breaking circuit at the moment when the pendulum-rod is vertical, and an additional tilt hammer being available for interrupting the circuit at the instant of extreme elongation on alternate seconds. Mr. Dean availed himself of this means for measuring the personal error of noting signals, by connecting each tilt hammer with a separate circuit. One of these passed through the normal signal-apparatus of the clock, the Morse register, the signal key, and the galvanometer; the other through the subsidiary tilt hammer, the observing key, and the chronograph. The original signals were thus recorded on the chronograph sheets by means of a clock-scale graduated to two seconds, while the observations of the same were registered upon the Morse fillet; and a slight change made in the connections at the close of the experiments sufficed to put the records of both tilt hammers upon the chronograph, and thus permit an accurate measurement of the interval between the two systems of clock-signals. In the first-named circuit a battery of two carbon cells was employed, resistance-coils being interposed to reduce the deflections of the galvanometer to the magnitude of those obtained through the cable; and the chronograph magnet proved sufficiently sensitive to record these.

On November 10, five series of measures gave for his personal error from all 0·236 + 0·009.

On the 12th November, again, his observations of twelve sets of signals give, after deducting 0·48s. from each to correct for the difference of the two time-scales gave from all 0·192s. ± 0·009s.

The marked inferiority of these values to those found for three observers, on two different occasions at Valencia, excited my suspicions, and on inquiry of Mr. Dean it proved that his observations had been made in the same room in which Mr. Goodfellow had given the signals, and where the click of the key was distinctly audible, so that the observation was not purely dependent upon the deflection of the needle, but was possibly influenced by the sense of hearing.

Mr. Dean therefore repeated his observations under circumstances precluding the possibility of his personal error being affected by any extraneous influence of this kind. This was done on November 17, and ten series of signals (one of the original eleven being discarded for manifest irregularity) afford the following result, in which the difference of time-scales is included, the definite value from the ten series being 0·830s. + 0·008s.

For the difference of the time-scales 52 comparisons, during one minute preceding the observations, give 0·491s., and 60 comparisons immediately afterwards give 0·499s. Adopting 0·495s., therefore, as the most probable value, and deducting this from the final value 0·830s., we have 0·335s. as Mr. Dean's personal error in noting the signals.

The difference between this error and that found for my own observations at Valencia is small, and is probably owing to the galvanometer rather than the observer; the apparatus at Heart's Content being known to be somewhat less sensitive than that at Foilhommerum. The constancy of the error is also here strongly manifest; and the illustration of the unrecognized but marked effect of the sound of the tap, upon observations supposed to be of the visible deflection only, is instructive.

It may not be inappropriate to mention in this connection that a very marked effect upon the observation of transits of stars is likely to be produced when the chronograph is in the same apartment, so that the regular beats of the magnet are audible. When the interval between the transit threads are approximately multiples of half a second, the tendency is very great so to tap upon the observing key as to produce a rhythmical beat in the armature; and when the interval differs from the multiple of a second, the occurrence of that magnet beat which records an even second often precipitates the tap of the observer, whose nerves are in keen tension awaiting the instant of bisection. Only a strong effort of will can obviate these perturbing influences—which are akin to those exhibited in the measurements just described.

The personal error of noting being then assumed as 0·271s. at Valencia, and 0·335s. at Newfoundland, the sum of these quantities, or 0·606, is to be deducted from our value of $x_1 + x_2$ to obtain the true time of transmission; and half their difference, or 0·032, is to be deducted from the longitude after all other corrections are applied. This correction will be taken into account, in fixing the value to be adopted.

It may be added that the indications are strong that a considerable portion of this "personal error of noting" is not strictly a personal phenomenon, but that it is due to the consumption of a very appreciable interval of time in overcoming the inertia of the needle and in moving the needle through an arc sufficient to attract attention. Indeed, it is my conviction that not less than the tenth of a second is thus lost.

An automatic apparatus might be arranged, all other means failing, for recording the signals received, by adjustment of delicate silver wires on each side of the galvanometer needle, in such a position, and so connected with the battery, that they would be brought in contact whenever the deflection of the needle reached a certain angle, and the signal be thus recorded upon the chronograph. This would definitely decide the question; but, for obvious reasons, no such experiment was undertaken at Valencia. My immediate object was thoroughly attained by the satisfactory results of these measurements of the sum of all delays not due to time consumed in the actual transit of the signals across the Atlantic.

THE BEERIZING OF TIMBER.

Mr. Sigismund Beer, in a communication to the November No. of this *Journal*, page 324, finds himself prompted to criticise some remarks on the "Beerizing Process," in my articles on the preservation of timber.

He states, in the first place, that the description of the process which I had given is very defective, without, however, pointing out in what these defects consist. To this I would reply that the first knowledge which I gained on the Beerizing of timber was from a pamphlet of the inventor, and after this I noticed an article on it in a German periodical of the Grand Duchy of Hesse, which was copied from there by the *Polytechnic Journal of Dingler*. Having this former paper just at hand, and being satisfied that it contained materially the same information on the subject as the pamphlet of Mr. Beer, I did not hesitate to make use of it, the more so as shortly before I had perused several other articles on the process of Beerizing, which, however, I happened not to have on hand. But, if the description of the German periodicals are defective, I am unable to comprehend why Mr. B. did not complete it, especially when it is known what a large circulation one of them possesses. Still the main point in Mr. B.'s invention consists in "boiling the lumber in a solution of borax," and this I stated. The assertion of Mr. B. that I offered my services as correspondent for American and foreign papers, I positively deny.

In referring to my description he then says:—

> "I know too well the uselessness of any coating to preserve wood, because, if the fermentive matter is left in wood, it will decay within; and if the sap is removed from wood then coating is quite unnecessary, as pure wood cannot rot, whatever may be its exposure to water or air, or both together."

If Mr. B. means by "coating" merely an external application, I perfectly agree with him, but on the other hand, wood that is apt to decay may become perfectly imperishable, if the preservative is applied in such a manner that it will surround the fibres themselves. This end may be attained in impregnating the timber with substances that enter with the sap-matter either into an insoluble mixture or chemical compound. Sometimes the tree contains those elements in itself. As to instances of that kind I refer the reader to the third part of my article on Various Processes for Preserving Timber, on page 346 of this *Journal*. With regard to the further statements of Mr. B., quoted above, I am in perfect harmony with him, and not only do I not know of having ever expressed another opinion, but on the contrary, I held it always to be true that pure ligneous fibre is not liable to decay. As a proof of this, it may be allowed me to quote from an article entitled "Timber Rot," published by me in the *Engineering and Mining Journal*, of August 3, 1869. There I say:—

> "Sound timber, when immersed in water, without access of air, will withstand decay for almost an unlimited time. This is proved by the piles upon which the

dwellings on the Canaries rest, which were erected in the time of the Conquest, in 1402, they being just as sound now as if they had been freshly felled. Roots of trees that have been submerged in marshes are rarely found decomposed. This is stated to be the case with the utensils discovered in the lake dwellings of Switzerland, Bavaria and the Lombardy, which must be at least two thousand years old. Hartig also describes a cypress stem with over three thousand rings, representing the same number of years, which, though submerged, had only partially turned into brown coal."

"With respect to the action of the atmospheric air, it may be asserted that the same, even when moist, will not produce rot, if the wood has been well steamed, or exposed to the action of running water for a sufficient length of time. In England it is customary to lay the timber destined for threshing-floors and wainscoting in fresh water for several weeks. When again dry and not exposed to damp, such timber will endure for an incaedible period of time."

"This tends to demonstrate the fact that the substance which induces decay must be foreign to the timber itself. This substance is the juice that is chiefly contained in the vascular tissue, which forms a link between the bark and the wood. The composition of this sap varies according to circumstances, as the variety of the tree, climate, season, ground, etc."

And further on:—

"When air-dried, steamed, or chemically treated and afterward dried wood commences to rot, it is a sign that the sap had not been entirely removed, and that moisture has again penetrated. Timber decomposes the easier, the more sap it contains, and if green trees are hewn when the vessels are overflowing with juice, one may look with certainty for diminished durability of the timber."

Still, though all this may be granted, the question arises, will Beerized or any other wood that has been freed from sap-matter be secured against the ravages of that large class of boring worms that threatened the existence of Holland more than once,* in destroying the wooden levees along the coast, and that cause so much loss to the shipping trade and submarine constructions? I will remark that the damages of the naval worm have called forth repeated investigations from the part of men of science, the earliest of these being laid down by Sellius, of Utrecht, in 1733, in a 4to. volume of 350 pages. Those worms, and, perhaps, a great many more, *live from the woody fibre*, attacking it whether it is free from sap-matter or not. Still, Mr. B., in his pamphlet, *Our Malpractice in Curing Timber*, asserts that wood prepared by his process is vermin-proof. Further on, Mr. B. states that "borax" as well as "pure wood" are antiseptics. This is a new discovery, which I gladly leave to Mr. B.; but, without entering into such minor points, a discussion of which could scarcely benefit the reader of this *Journal*, I will now give the authorities for my statement that borax will likely attack wood, or, rather, the material covering the cellular substance of ligneous tissues. This substance predominates especially in hard woods, and has been called, by PAYEN, "*matière incrustante;*" HARTIG denominates it "*intercellular substance;*" while Messrs. FREMY and PELOUZE embrace the elements constituting them under the term "*corps épiangiotiques,*" from ἐπὶ, upon; ἀγγετω, vessel.

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* In the years 1660, 1731, 1759, 1770, 1827, and 1858.

I translate from Vol. IV., page 746, of the "*Traité de Chimie génerale, analytique, industrielle et agricole*" of MM. PELOUZE and FREMY, the following passage:—

"Mr. PAYEN has not found the same elementary composition for the incrustating substance (*substance incrustante*) of different kinds of wood: he recognized four distinct bodies, which he designated by the terms *lignose*, *lignone*, *lignin* and *ligniréose*.

1. The *lignose* is insoluble in water, alcohol, ether and ammonia, but soluble in potassa and soda.

2. The *lignone* is insoluble in water, alcohol and ether, but soluble in ammonia, potassa and soda.

3. The *lignin* is insoluble in water and ether; soluble in alcohol, potassa, soda and ammonia.

4. *Ligniréose* is not soluble in water, and soluble in alcohol, ether, potassa, soda and ammonia."

From this it appears that the intercellular substance is soluble in alkalies: one of its parts is even taken up by alcohol and ether. Borax being of a slightly alkaline nature, I therefore thought to be justified in drawing the conclusion that the treatment of wood, as practiced by Mr. B., would affect the ligneous tissue.

The inventor says, further:—

> "Paper-makers, who use wood, would do well to dispense with potash or soda, and obtain a license to use borax, or a like compound, to purify wood from its non-fibrous matter, and I had them mainly in view in claiming the right of my process for purifying wood also."

This passage I find rather unexpectedly in the pen of Mr. B.; whether he means to make the statement that borax is alike to the alkalies in its efficacy in preparing paper-pulp from wood, or whether he supposes that this operation consists simply in the removal of the sap and silica, I am unable to say.

The experiment of Mr. B., illustrating the deportment of a borax solution towards the white of an egg, undoubtedly has incited interest; however, I cannot adopt it as a proof against my view of the subject, as animal membrane can scarcely be compared with the vegetable material referred to.

As regards my statement that a part of the albumen, originally contained in wood, has been retained in it after treating the same with borax, I hesitate not to mention that I owe it to a gentleman in whose veracity I formerly never had reason to doubt; still, I am glad to be informed that no albumen is retained, and that the main feature of the Beerizing Process is an undeniable fact.

ADOLPH OTT.

New York, December 1st, 1869.

ON THE NEW CHEMICAL NOMENCLATURE.

BY DR. ADOLPH OTT.

(Continued from Vol. LVIII., page 333.)

HUMPHRY DAVY, in 1812,* proposed to denominate the lower chlorinated compounds by the termination *ane*, and the higher ones by *ana*, if only one distinct combination was known by *ane*. Common salt was called *sodane*, the protochloride of iron *ferrane*, the perchloride of arsenic *arsenicana*. "Some persons," he says, "may choose rather to use the word chloride, following the analogy of oxide; but, as I have expressed in the introduction, our nomenclature would have been more simple and useful without any attempt at theoretical expressions of the composition of bodies; and as the fixed alkalies, earths and oxides, are similar bodies, and the termination *a* has been applied to the two first, it might be properly extended to the last."—The only relic of this scheme which we meet with in the literature of the present day, is *Azotan*, which is alluded to in Watts' Dictionary of Chemistry, as "a name not much used, for chloride of nitrogen."

Albeit some similarity is found among the old names of the elementary bodies, of which we propose to speak first, yet they are, on the whole, entirely arbitrary. But few of these elements were known to the ancients and these are easily preserved in a separate state, such as gold, silver, iron, copper, sulphur, carbon, &c. The names of some of the more recently discovered elements have been rendered significant by deriving them from the Greek ety-

* Elements of Chemical Philosophy, Vol. I., p.6.

mology, which would designate a characteristic property, *e.g.*, oxygen, chlorine, iodine, bromine, &c. Other elementary bodies have been called after the best known compound. Among these we may mention potassium, sodium, aluminum, and silicon. The terms strontium and yttrium commemorate the name of the place where originally found. Palladium, pelopium, tellurium, uranium and others are derived from classical mythology, and thorium and vanadium from the Scandinavian. Finally, the color of their lines in the spectrum has determined the naming of caesium, rubidium, thallium and indium.

A celebrated chemist* has expressed the opinion that names of elementary bodies should be formed fulfilling the following conditions:—

1. Of being simple, euphonic and in harmony with the names to which we are habituated.
2. Of being able to adapt themselves to all languages, and
3. Of being easy to retain in the memory, so that the nomenclature in actual use may be abandoned, and the new one adopted with but a slight effort to memory.

If the author of this should be called upon to accomplish the difficult task of creating new names for the chemical elements, he would also endeavor to institute a distinction between the metalloids and metals, and, if possible, adopt equal terminals for the latter class, which embraces by far the greater number of elements. We may consider it as a matter of great congratulation to the chemists on this side of the Atlantic that one of their colleagues not only has fulfilled these desiderata, but constructed a scheme by providing names for every well investigated body, which at once designates the kind and number of atoms, and to a certain extent, also its typical and functional characteristics.

The system, which we shall now commence to examine, "is based on abbreviations of the universally received names of the metals, and on the chemical symbols of the metalloids or non-metallic elements, with such modifications as were imperatively required."†

The names of the metals consist of two syllables, the first syllable is a part of the present name as recognized by every nation, while the second syllable invariably terminates with the consonant *m*, which is already the termination of a majority of the names of metals. In the twelve cases where the same metal is known by two names, each name has been adapted to the new system. Arsenic and tellurium, regarded by some chemists as metalloids, (for reasons, which need not be here given,) have, in the new system, the terminal letter common to the metals. With regard to the metalloids, they all end with a letter different from *m*. The names of fluorine, nitrogen, carbon, bromine, phosphorus and sulphur terminate in the new system with their well known symbolic letters, viz: *f*, *n*, *c*, *b*, *p* and *s*, and only in a few cases where the symbolic letter could not be adopted, terminal letters have been used which refer to some characteristic property of the respective element. The name of hydrogen ends with the consonant *l*, *l* representing the *lightest* of substances, the name of chlorine with *d*, *d* representing the *densest* of the gaseous elements; *v* representing a *volatile* producing a *violet* vapor, *v* is therefore employed as terminal for the name of iodine. That element, exceeding in quantity all others of the earth's crust, or, according to spectroscopic revelations, those of our solar system, ends with *t*, the name for one single atom of oxygen, being *oxat* or *at*. The denomination for selenium terminates with *z*: it bears a strong resemblance to sulphur, the name of which ends in *s*; indeed, sulphur and selenium have long since been classed together as bodies of equal atomicity.* The solids boron, silicon and carbon will be remembered by *j*, *k* and *c* or *r*, respectively. The letter *r* may be associated with the radiating and refracting power of carbon.

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* Auguste Laurent, Chemical Method, Notation, Classification, and Nomenclature. London, 1855. page 356.

† Proceedings of the American Association for the Advancement of Science, 16th meeting. Cambridge, 1868, vide page 50. A NEW CHEMICAL NOMENCLATURE. By S. D. Tillman, of New York, N. Y.

The originator of the new nomenclature has also provided distinctions for the number of atoms, or smallest indivisible quantities of an element. These are designated by the vowel immediately preceding the terminal consonant representing a given element. The numerical power of the vowels advances with their order in the alphabet. *One*, *two*, *three*, *four* and *five* are respectively expressed by *a*, *e*, *i*, *o* and *u*, with short or stopped sound. The numbers *six*, *seven*, *eight*, *nine* and *ten* are respectively expressed by *ea*, *ee*, *ei*, *eo*, *eu* (*e* having in this series the numerical power of five, in fact used to give the long sound to the succeeding vowel), so that their respective full sounds may be as heard in the five following words, *great*, *heed*, *sleight*, *yeoman*, *feudal*.

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* **Dumas**, "Traite de Chimie appliquee aux Arts," Vol. I., page ixxvii., 1828.

In foreign languages, it may be best to designate the long sound by a sign placed *over* the vowel; but in our language it is found by experience more convenient to place *e* before each vowel for the purpose of giving it the long sound. We may illustrate these ten distinctive sounds in the following, in which the atoms of the most recently discovered element, from one up to ten, have these names:

In Indam, In_2 *Indem*, In_3 *Indim*, In_4 *Indom*, In_5 *Indum*, In_6 *Indeam*, In_7 *Indeem*, In_8 *Indeim*, In_9 *Indeom*, In_{10} *Indeum*.

For the atomic numbers higher than ten, the rules will be presently given, and selections will be brought that will clearly indicate the numerical value of each letter.

It is remarkable that by combining the consonants representing the non-metallic elements with the vowels representing numbers of atoms, the author of this nomenclature has already given new names and terminals applicable to more than *seven thousand* known chemical compounds.

When Lavoisier and his coadjutors framed our present nomenclature, an exclusive importance was attached to the element oxygen, which is easily explained, as the greatest number of compounds known to them contained oxygen as one of their constituents. "The facts concerning the composition of acids, oxides and of salts, composed almost the whole domain of chemistry."* The generic denomination oxide was applied to neutral bodies and bases, and in order to express a specific compound the name of the other element was joined to it. In order to distinguish two compounds with variable quantities of oxygen, the prefix *proto* was applied to the oxide, containing the least proportion of oxygen, while *deuto* and respectively *trito* were joined to those containing more oxygen. Subsequently the Latin particle of intensity *per* was more commonly used as a prefix in order to designate the highest degree of oxidation, and *sesqui* was introduced to denote oxides whose atomic composition was expressed by the ratio 2 : 3. These prefixes were also applied to the analogous halogen compounds. The founder of the dualistic doctrine, Berzelius, rejected these prefixes, using for the denominations of compound bodies an adjective, composed of the first or two first syllables of the Latin name of the respective element and the terminal *ous* or *ic*, and to these the name of the genera (oxide, chloride, &c.,) was added. Latterly this system has again come into use in a somewhat altered form. With respect to the acids, it was supposed by the Lavoisierien school that one element could only form two acid compounds with oxygen. Such compounds were composed of two names, an adjective and a name of the genera, (in this case "acid,") they being distinguished by the terminal *ous*, adjoined to the adjective, when less, and by *ic*, when more oxygenated. With the increase of well-investigated chemical bodies, it became necessary to modify this rule. The prefix *hypo* was thus applied to less oxygenated, as also to acids intermediate to those already known. However, this was only a temporary relief, for in latter years some new combinations were discovered, that were comprised between the two least oxygenated acids, also acids were found containing more oxygen than those for which the terminal *ic* had been appropriated. For these new changes had to be introduced, although according to the rules upon which the fundament of the present nomenclature rests, the specific term of the highest oxygenated compound should receive the terminal *ic*, in lieu of those which they bear now. But, these designations being once adopted, cannot now be readily rejected without leading to serious consequences, unless the old nomenclature be supplied with a new scheme that will enable chemists to express their views more concisely. Reserving for a future paper an elucidation of the modifications proposed by Dumas, Laurent, Gmelin, Watts, Williamson, Foster and others, we deem it proper to annex hereto a table of chemical symbols and names by Prof. S. D. Tillman, as communicated to the American Association.

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* A. C. WURTZ, An Introduction to Chemical Philosophy according to modern Theories. London, 1867, page 188.

This table embraces all the elementary bodies known with certainty, and their atomic numbers corresponding with the systems of Berzelius and Gerhardt, to each of which the new names are equally applicable. The highest and lowest known oxides of each element are also added. Names included in brackets are hydrates containing three elements.

METALLOIDS.

SYMBOLS.	At. wt. al = .5	At. wt. al = 1.	Name of one atom.	Name of a molecule (2 at)	Name of lowest oxide.	Name of highest oxide.
H	·5	1·	Hydral	Hydrel	H_2O *hydrelat*	H_2O_2 *hydrelt*
N	7·	14·	nitran	Nitren	N_2O *nitrenat*	N^2O_5 *nitrenut*
O	8·	16·	oxat	oxet		
C	6·	12·	carbac	carbec	CO *carbart*	CO_2 *carbaret*
	"	"	carbar	carber		
Si	14·	28·	silak	silek		SO_2 *silaket*
B	5·45	10·9	boraj	borej		B_2O_3 *borejit*
P	15·5	31·	phosap	phosep	PO *phosapt*	P_2O_5 *phoseput*
S	16·	32·	sulphas	sulphes	SO_2 *sulphaset*	SO_3 *sulphasit*
Se	39·75	79·5	selaz	selez	SeO_2 *selazet*	(*alazot*)
F	9·5	19·	fluraf	fluref		
Cl	17·73	35·46	chlorad	chlored	Cl_2O *chloredat*	(*aladot*)
Br	40·	80·	bromab	bromeb		(*alabit*)
I	63·5	127·	idav	idev	HIO (*alavat*)	I_2O_7 *ideveet*

METALS.

Symbols.	At wt. al. = 5.	At wt. al. = 1.	Name of one atom.	Name of a molecule (2 at.)	Name of lowest oxide.	Name of highest oxide.
Cs	66·5	133·	Cœsam	Cœsem	Cs_2O *casemat*	(*casamalt*)
Rb	42 5	85·	rubam	rubem	*rubemat*	(*rubamalt*)
K	19 5	39·	kalam *or*	kalem	*kalemat*	(*kalamalt*)
"	"	"	potam	potem	*potemat*	(*potamalt*)
Na	11·5	23·	natam *or*	natem	*natemat*	(*natamalt*)
"	"	"	sodam	sodem	*sodemat*	(*sodamalt*)
L	3·5	7·	litham	lithem	*lithemat*	(*lithamalt*)
Ba	68·5	137·	baram	barem	BaO *baramat*	*baramet*
Sr	43·8	87·6	stronam	stronem	*stronamat*	*stronamet*
Ca	20·	40·	calcam	calcem	*calcamat*	
Mg	12·15	24·3	magam	magem	*magamat*	
Al	13·7	27·4	alam	alem	*alemit*	
G	4·7	9·4	glucam	glucem	*glucemit*	
Zr	44·75	89·5	ziram	zirem	*ziremit*	
Th	119·	238·	thoram	thorem	*thoramat*	
Yt	30 85	61·7	yttram	yttrem	*yttramat*	
E	56·30	112 6	erbam	erbem	*erbamat*	
Tb			terbam	terbem	*terbamat?*	
Ce	46·	92·	ceram	cerem	*ceramat*	*cerimet*
La	46 47	92 94	lanam	lanem	*lanamat*	
Di	48·	96·	didam	didem	*didamat*	
Zn	32·75	62·5	zinam	zinem	*zinamat*	(*zinamelt*)
In	35·91	71·82	indam	indem	*indamat*	
Cd	56·	112·	cadam	cadem	*cadamat*	
Co	29·50	59·	cobam	cobem	*cobamat*	*cobemit*
Ni	29·87	58·74	nikam	nikem	*nikamat*	*nikemit*
U	60·	120·	uram	urem	*uramat*	*uremit*
Fe	28·	56·	ferram *or*	ferrem	*ferramat*	*ferremit*
"	"	"	iram	irem	*iramat*	*iremit*
Cr	26 27	52·54	chram	chrem	(*chramalt*)	*chramit*
Mn	27·50	55·	manam	manem	*manamat*	*manamet*
Sn	59·	118·	stanam *or*	stanem	*stanamat*	*stanamet*
"	"	"	tinam	tinem	*tinamat*	*tinamet*
Ti	25·	50·	titam	titem	*titamat*	*titamet*
Nb	49·13	98·26	nobam *or*	nobem	*nobemit*	*nobamet*
Cl	"	"	colam	colem	*colemit*	*calamet*
Ta	91· ?	182· ?	tanam	tanem	*tanemit*	*tanamet*
Mo	48·	96·	molam	molem	*molamat*	*molamit*
V	68·46	136 92	vanam	vanem	*vanamat*	*vanemit*
W	92·	184·	wolam	wolem	*wolamat*	*wolamit*
"	"	"	tunam	tunem	*tunamat*	*tunamit*
As	37·5	75·	arsam	arsem	*arsamat*	*arsamut*
Sb	60·15	120·3	stibam *or*	stibem	*stibamat*	*stibamut*
"	"	"	antam	antem	*antamat*	*antamut*
Bi	105·	210·	bisam	bisem	*bisamat*	*bisamot*
Cu	31·75	62 5	cupam *or*	cupem	Cu_2O *cupemat*	*cupamet*
"	"	"	coppam	coppem	*coppemat*	*coppamet*
Pb	103·5	207·	plubam *or*	plubem	*plubemat*	*plubamet*
"	"	"	leadam	leadem	*leademat*	*leadamet*
Tl	101·75	203·5	thallam	thallem		*thallamit*
Te	64 5	129·	tellam	tellem	*tellamet*	*tellamit*
Hg	100·	200·	hygam *or*	hygem	*hygemat*	*hygamat*
"	"	"	mercam	mercem	*mercemat*	*mercamat*
Ag	54·	108·	argam *or*	argem	*argemat*	*argamet*
"	"	"	silvam	silvem	*silvemat*	*silvamet*
Au	98·33	196·66	auram *or*	aurem	*auremat*	*auremit*
"	"	"	goldam	goldem	*goldemat*	*goldemit*
Pt	98·56	199·12	platam	platem	*platamat*	*platamet*
Pb	53·24	106·48	pallam	pallem	*pallemat*	*pallamet*
Ro	52·16	104·32	rhodam	rhodem	*rhodamat*	*rhodemit*
Ru	52·11	104·22	rutham	ruthem	*ruthamat*	*ruthamet*
Os	99·41	198·82	osmam	osmem	*osmamat*	*osmamot*
Ir	98·56	197·12	irdam	irdem	*irdamat*	*irdamet*

ECLIPSE OBSERVATIONS AT MATTOON, ILLINOIS.

By Prof. G. W. Hough.

The station chosen by the Dudley Observatory party for the observation of the total Eclipse, was at Mattoon, Illinois.

The latitude and longitude of the station had previously been determined by the United States Coast Survey. Latitude 39°, 29 minutes, 10·5 seconds. Longitude 45 minutes, 20·2 seconds west of Washington.

Prof. J. H. C. Coffin, Superintendent of the Nautical Almanac, kindly furnished us with the necessary data for the observation of the phenomena.

Observers.

The corps of observers was composed of the following persons: Prof. David Murray, Rutgers College, New Brunswick; Mr. Lewis Swift, Marathon, N. Y.; Mr. J. C. House, Waterford, N. Y.; Mr. Thomas Simons, New York City; Prof. L. M. F. Esterday, Hillsboro, Illinois; Prof. Twining, St. Louis; Rev. Mr. Marshall, Indianapolis; Gen. J. W. Keifer, Springfield, Ohio; C. B. Bostwick, Mattoon, Ill.; Prof. F. H. Smith, Mattoon, Ill.; President Thos. Hill, Cambridge, Mass.; Prof. G. W. Hough, Dudley Observatory.

The station at Mattoon was near the west side of the school building, twenty feet north of the South monument, erected by the United States Coast Survey. The position was a good one, as there was an uninterrupted view to the south, west and east.

In the south-west room was mounted the Sidereal clock and Chronograph. The clock was a mercury compensated pendulum, made in two sections for facility of transportation; the mercury being held in an air-tight iron cylinder. This clock was made expressly for the Eclipse expedition by Charles Fasoldt, of Albany, to whom we are also under obligations for a mean time pocket-chronometer, beating three times per second.

Before packing, the clock was set up in the Observatory and rated on Sidereal time, and the necessary connections attached for recording minutes and seconds on the Chronograph. Its running for nearly a week, as compared with the standard clock, showed a steady and reliable rate. On arriving at Mattoon, August 2, it was immediately mounted on a solid brick wall, and started on Mattoon Sidereal time, as deduced from the watch, by applying difference of longitude, &c. In the afternoon of the same day, by comparison with the watch, it was found going too slow. A small brass weight, equivalent to five seconds per day on the rate, was placed on the pendulum; after which time it was not disturbed. By subsequent comparisons with Dudley Observatory time, observed by means of the telegraph, its rate was ascertained to be fifteen seconds slower, daily, and the arc of oscillation a little shorter than when running at the Observatory. On its return, after being cleaned, it was again set up, when the rate was found to be essentially the same as at Mattoon.

Time.

To Mr. Orton, the President, and Gen. Anson Stager, Superintendent of the Western Union Telegraph Company, we are especially under obligations for putting a continuous line of telegraph wire of nearly one thousand miles in length at our disposal, for the purpose of securing time from the Dudley Observatory. Our thanks are also due to the managers of the following offices, all of whom were interested in the success of the work: Mr. C. S. Jones, manager of the Albany office; Messrs. Hucker and Slacer, Buffalo; Messrs Wright and Tindall, Cleveland; Messrs. Armstrong and Warren, Cincinnati; Mr. J. F. Wallack, Indianapolis; Mr. Patton, of Mattoon. The necessary connections at the Dudley Observatory were made by Mr. Thos. E. McClure and Mr. H. L. Foreman.

A continuous circuit was secured on the nights of the 5th and 7th, when the Dudley Observatory sidereal and mean time clocks were compared with the clock and chronometer at Mattoon.

The mean daily rate of the clock was found to be 15·54 seconds slow. As the last comparison with the Dudley Observatory time was only 5 hours after the Eclipse, it is presumed the time was very accurately determined.

Chronograph.

The chronograph used for the Eclipse observations was of the cylinder form, and was constructed expressly for this purpose. The cylinder was 6 inches in length and 10 inches in diameter, driven by clock-work regulated by the Fraunhofer friction balls. For securing a motion of stable equilibrium, an escapement, held by a light spring, was connected with the shaft next to the friction balls, which was regulated by a magnet beating every two seconds, by opening and closing the circuit with the pendulum of the clock. The sheets were previously ruled for every minute, and the clock dots were recorded every two seconds. A second pen was employed for recording the observations. The connections were so arranged on the clock that at the end of every minute the clock-pen recorded in addition the 61st second, thereby giving the zero of the clock with absolute certainty—the whole mechanism performing in a very satisfactory manner. In order to enable more than one observer to use the chronograph during the progress of the Eclipse, wires were connected with the clock-pen and battery so that observations could also be recorded with it. It was so used by Mr. Lewis Swift.

Another set of wires were connected with a battery and local sounder-magnet placed near the observers. This magnet gave the clock-beats for every two seconds and the extra beat at the 61st second, by making connection through the clock-pen, causing it to act as a repeater.

The Telescope.

The telescope employed by myself was the Comet Seeker, made by Alvan Clark. The focal length is three feet six inches, and the objective four inches clear aperture. A parallel wire micrometer and position-circle divided to degrees, was constructed for this work. There was one fixed vertical and one horizontal wire, and three movable micrometer wires. The eye-piece holder was so constructed that the eye-pieces belonging to the transit instrument could be used. A brass screw, held in position by a set screw, was fitted over the eye-piece to which was attached a disk of brass, three and a quarter inches in diameter, in which was set six plates of glass of different colors and density. One of these orifices was arranged to hold two or three thicknesses of glass, as the occasion demanded. In the same disk of brass was an opening without any glass, for observing the total phase. The brass plate holding the glass screens revolved on a centre, so that any colored glass could readily be brought in front of the eye-piece.

For regulating the aperture of the objective, holes of one, two, three and four inches in diameter were cut in a disk of thin card board. This was firmly screwed to a block and made to revolve in front of the objective by means of a hand rod, attached to the side of the telescope-tube. A spring dog, dropping in a notch, always brought the opening over the centre of the objective.

The telescope was equatorially mounted with hand rods for giving slow motion in right ascension and declination.

A day or two previous to the Eclipse, three posts were firmly set in the ground for the observing stand. The telescope was brought in the meridian and appropriately adjusted for the latitude of the place, by observations on the sun made some time previous to the beginning of the Eclipse.

The eye-piece used during the Eclipse gave a power of 44.

The night preceding the day of the Eclipse was one of unusual anxiety to the observers, from the fact that about six o'clock it began to rain, and continued, almost without intermission, until 11 P. M. In order to learn the worst, we went to the telegraph office and asked for weather reports from west and east. At nearly all the stations from which reports were received, extending from Omaha to Cincinnati, it was rainy or cloudy. These reports led us to expect a storm extending over a large area of territory, and it was presumed that it would be a day or two in passing over; but, fortunately, our prognostics were in error, for, at 11 o'clock, P. M., the rain ceased and stars began to make their appearance. The morning of the 7th was perfectly clear, with not a cloud to be seen, and it so continued during the whole day and subsequent night. It was one of those rare days but seldom seen in this climate; the atmospheric disturbance being at a minimum.

One hour before the beginning of the Eclipse, observations were made on the solar spots, and their position and magnitude mapped on a diagram prepared for the purpose. As the time drew near for the first contact of the moon's limb, each observer examined carefully the region where the moon was expected, to see whether it would be visible, before contact, with the solar disc. The closest scrutiny of five observers failed to discover it.

At 10 seconds before the true contact of the limbs, a lunar mountain, distant 8 or 10 degrees north of the contact point, plunged into the solar disk and was recorded on the chronograph. The true contact of the limbs was well observed by all, and at nearly the same instant. The moon's limb, instead of appearing round, as it should, was nearly flat and a little notched, showing a mountainous region. As the Eclipse advanced, observations were made by means of the micrometer and chronograph for measuring the relative position of the two bodies. When the sun was about half eclipsed, a red band of light was seen surrounding the limb of the moon over the solar disc. Later, during the progress of the phenomenon, tails of light were seen projecting out, tangent to the moon's limb, and extending 15 or 20 degrees along the edge.

As the crescent of solar light grew less and less, every eye was intently watching for any unusual appearance. Nearly a minute before totality, we saw, with wonder, a red flame suddenly shoot out from the upper edge of the moon, and shortly after, the remarkable and beautiful phenomenon of Bailey's Beads. The slender crescent of light was suddenly broken up in numerous globules, resembling drops of water flowing together, or a string of beads. One observer compared it to a string of sausages of unequal lengths.

This peculiar breaking up of the solar crescent was noticed by Bailey in 1836; but during subsequent eclipses it has not generally been seen. This fact has led some of the ablest astronomers to doubt its reality, believing it to be an optical illusion.

At Mattoon, the appearance was distinctly seen by all the observers, and its duration recorded on the chronograph by Mr. Swift and myself. That the phenomena is real we have no doubt. It is well known that the limb of the moon is exceedingly rough and jagged, with mountains projecting to a great height. Now, it is reasonable to suppose that when this mountainous limb of the moon cuts off the slender crescent of light it must be more or less broken up in sections, depending on the irregularities of the surface and the position of the observer. We are more strengthened in this opinion since, previous to the first contact, Mr. Swift saw five mountain peaks on the moon, and he reported the beads the most conspicuous in the region towards this part of the lunar disc

The duration of Bailey's Beads was accurately recorded on the chronograph by Mr. Swift and myself, and found to be 5½ seconds. This is the first exact record ever made for the duration of the phenomena.

As the light grew less and less, suddenly the sun seemed to dart under the black disc of the moon, producing a feeling of chilliness. Now was seen, in all its splendor, the large red protuberance sitting on the edge of the moon, and appearing very much like a great ship under full sail. Farther to the left was another, nearly as large, with two bent rays, somewhat resembling the antlers of a deer. Five others, not quite as large, were seen on different parts of the disc, all of a deep red color.

After looking with astonishment for a few seconds, we proceeded to measure with the micrometer the height and position of the largest flames; but, just at the critical moment, fortunately or unfortunately, one of the hand-rods for moving the telescope came off, and it was necessary to remove the eye from the tube to fix it. On looking up, one of the grandest spectacles met the eye of which it is possible to conceive; surrounding the dark body of the moon was a crown of light, with rays shooting out, in five great sheaths, to a distance equal to the sun's diameter, or nearly a million of miles. For a time everything else was forgotten, and we gazed for 8 or 10 seconds with astonishment, akin to awe, at this magnificent spectacle. No painting can represent it, and no pen can describe it. It is one of those sights which must be seen to be appreciated. But we soon realized that precious moments were slipping away. The telescope was again brought into position, and the height of the large protuberance measured, and found to be 1′ 05″, or about thirty thousand miles, and one hundred thousand at the base.

While still gazing, a ray of light suddenly flashed out, and the Total Eclipse of August 7th was over.

The duration of totality, according to the chronograph records, was two minutes and forty-two seconds. The large protuberance, however, remained visible for five minutes and fifty seconds after the sun had appeared, or, as Mr. Swift reports, until it was apparently lifted up by the advancing crescent of solar light.

Stars Visible.

Previous to the beginning of the Eclipse, we set up a number of light wooden rods, indicating the direction of stars and planets. Prof. Twining and Mr. Marshall succeeded in seeing Saturn eight minutes before, and Venus four minutes before, totality. During the totality, Mercury, Venus, Mars, Saturn, and a number of bright stars, were visible to the naked eye.

Temperature.

Observations made by Prof. Smith, with a thermometer exposed to the direct rays of the sun, showed a variation of 42° during the progress of the Eclipse.

The observations of Mr. House, with a thermometer placed in the shade, showed a variation of 13°.

Prof. David Murray, at my request, prepared the paper on the physical phenomena, which is hereto appended.

Physical Phenomena.

The peculiar phenomena which have attracted so much attention in solar eclipses are only visible during the brief period of totality.

This, in the present case, only extended through two minutes and forty-three seconds. The difficulty in observing them lies in this exceeding brevity, and in the fact that, no matter how much the observer may have studied the experiences of others, the phenomena come upon him as a complete surprise. The moment the last ray of light disappears with the extinguishment of Bailey's Beads, there bursts upon him a vision so marvelously beautiful, so startling by its novelty, that his self-possession and self-control desert him, and leaves him, for an instant, a helpless gazer. As soon as he can collect his thoughts, and tries to marshal them into order, he will find especially two phenomena of notable interest.

I. *The Corona.*

In immediate contact with the solar disc it appears as a clear silvery light, as bright as the brightest part of an aurora, and somewhat resembling it in consistency. Farther out it appears streaked with pencils, radiating in the direction of the centre. These rays are more especially noticeable at five points of the circumference, two of them pointing upwards and outwards, and three having a general downward direction. These prongs could be traced through a distance even exceeding the diameter of the sun; and near one of them was visible a curved mass of light, in shape resembling the petal of a flower. On the upper edge of the disc was plainly seen an arch of light, parallel with the edge, and within the boundary of the corona.

It should be stated that this phenomena of the corona is best observed with the naked eye, and cannot be included within the field of any ordinary telescope.

Our party are indebted to the observations of Mr. Bostwick, of Mattoon, and General Keifer, of Springfield, Ohio, for the best configuration of the corona.

The commonly received explanation of the corona has attributed it to an atmosphere surrounding the sun, which was illuminated by the light of the sun in the same way that our atmosphere is illuminated in twilight. This will, undoubtedly, explain the lumiosity found nearest the disc, but it can hardly be received as satisfactory in regard to the luminous prongs which extend out to such a great distance. It must be remembered that these prongs projected a distance greater than the whole diameter of the sun, and must have reached an altitude, if they belonged to the sun, of at least a million of miles. This is, of course, beyond all possibility, and the idea of the whole phenomenon being of solar-atmospheric origin is untenable. Equally untenable must be the idea that it is a solar aurora, because an aurora supposes an atmospheric medium in which it exhibits itself.

The impression which was firmly made upon my mind by witnessing it was, that in some way, the interstriated part, at least, was formed in the earth's atmosphere.

II. *Red Protuberances.*

The second phenomenon attracting attention was that of the sudden appearance of a number of protuberances of various shape and magnitude, which projected beyond the black disc of the moon, and were of a bright rosy-red color. We saw six or eight in all. It must be remembered that these were of immense size: the largest was not less than 30,000 miles in altitude. They seemed to have a cloudy consistency, and the form of some of them forbade the idea that they could have been either solid or liquid. These protuberances are seen in all total eclipses, but in no two are they in the same place or of the same form; they are thus shown to be of a changeable and transitory character. This was really all that could certainly be known about them, until the application of the spectroscope to celestial bodies gave us a new road to a knowledge of them. By means of this we are able to distinguish a solid body from a gaseous, a self-luminous from a reflective body, and even more—to determine with certainty the very elements comprising the incandescent body. This mode of investigation, used first in the total Eclipse of 1868, and still more in that of the recent Eclipse, has revealed to us that the red protuberances are mainly a mass of incandescent hydrogen gas. The thought is overpowering. Here are vast accumulations of blazing matter, reaching to a height of many thousad miles. What convulsions in the matter of the surface of our sun does this view of it reveal!

That the spots which are seen on the surface of the sun will finally be proved to be identical with the protuberances I venture to predict.

III. *Floating Bodies.*

A few moments before totality, and during that period, nearly all the telescopic observers at our station noticed faint whitish bodies floating past their glasses. Prof. Hough saw three, Mr. Swift four or five, Mr. Simons five or six, Mr. House as many, and I saw four at least; at the time, they made no impression on my mind. I thought of thistle, down, or some other winged seed; others thought of midges which had been awaked by the darkness; others of swallows. But when we came to compare our observations and our conjectures, we found, to our surprise, that all these bodies had one direction, viz: from the north-west downward toward the south-east; and it seemed, therefore, impossible to explain them on any of the hypotheses which had been started.

The idea that they were meteoric, is, perhaps, more plausible, and it is strengthened by the fact that the time nearly corresponded to the August period of meteoric showers.

IV. *External Phenomena.*

No one who has not seen the phenomenon of a total Eclipse can appreciate fully the grandeur of the occasion. As the light, ray by ray, is cut off, a strange and ghastly darkness comes down upon us, not like the darkness of night, but a violet-colored darkness, which makes the faces of our neighbors turn ashy pale, and gives to the landscape the hues which it takes in a stereoscopic picture. I cannot better describe the appearances which strike an intelligent eye-observer, than in the words of President Hill, who, declining the use of all instruments, devoted himself to noting the external phenomena. He reports the results of his observations as follows:

"During the total Eclipse this afternoon, I was in the open field, near a small barn, about 1,600 feet west, and 550 feet south of your station. According to your request, I herewith give you a memorandum of what I noticed. This memorandum has been twice read to a party of five gentlemen, who were with me, and they agree, after full discussion, in every statement.

"A cow, grazing in the field, became uneasy at 5 o'clock, and started for home at 5 h. and 7 m. Soon after a hen gathered her brood under her wings. Swallows were skimming the ground. About two minutes before the total obscuration, about 70 cocks and hens went to roost in the barn. A flock of birds flew southward in a hurried and confused manner, just after the darkness became total. Soon after the re-appearance of the sun, the chickens came from under the hen; then the fowls came down from their roosts; and the cocks which had crowed occasionally all the afternoon, took it up by general consent, and crowed vigorously.

"No other animals were near us; no plants sensitive to light were in the field; and it was not until the Eclipse was over, that I discovered Cassia in an adjoining field. Some of us thought there was a slight deposit of dew upon the grass, but others failed to perceive it.

"Venus appeared a minute or two before the total obscuration, and remained visible for several minutes after the re-appearance of the sun. At the instant of total obscuration, Mercury, Arcturus and Vega appeared. Even Arcturus was of a silvery whiteness. Arcturus remained visible some seconds after the total phase had passed. We looked sharply for Capella, Procyon, Castor and Pollux, Regulus and Altair, and also looked less carefully for Saturn, Antares, Spica and Mars, but we had nothing but our general recollection of the stars to guide us as to the direction in which to look, and we saw nothing either with the naked eye or our opera glasses, beyond the two planets and two stars already mentioned. At the instant of total obscuration, one or two of us had a feeling that we were seeing half a dozen stars bursting into sight at once, but we could only find the two.

"The approach of the deep violet shadow in the air from the W. N. W., a little to the right of the sun, and its receding in the opposite quarter, was much slower and more majestic and beautiful than we had been led to expect. The gradual diminution of light during the Eclipse had revealed the presence of faint cirro-stratus clouds in the horizon of what appeared, both before and after the Eclipse, a cloudless sky. The transition from penumbra to umbra, although rapid, did not seem absolutely instantaneous. It was a sweeping upward and eastward of the dense violet shadow. This shadow then stretched from the W. N. W. to the E. S. E. horizon, while in the transverse direction it did not reach the horizon by 6 or 8 degrees, and the low arch beneath was one of a deep orange twilight. No difference was observed between the height of these arches. The transition from the orange-yellow of the northern and southern horizon to the dusky violet of the zenith, during the total phase, was at an altitude of 12 or 15 degrees, and then the violet seemed darker than in the zenith: as though two broad dark arches ran one on each side the zenith from W. N. W. to E. S. E.

"The corona appeared to us a white ring of 4 or 5 minutes in breadth, with white rings 30 to 35 minutes in length, and a few white petals 6 or 8 minutes in length, one of which, on the right hand upper limb, was curved. No change was observed in the corona, during the total phase, except that one of us thought there was a tremulous flashing at the instant before the re-appearance of the sun.

"A crimson cloud on the lower limb was particularly brilliant. One on the left limb was brilliant at the beginning, and one on the right limb at the end of the total phase."

It is almost unnecessary to add anything to this graphic description of Dr. Hill. A lady told me that the evening primroses in her garden, at the coming on of the eclipse, opened their petals as at the approach of evening. The owner of an unruly cow told us that she was kept in a pasture adjoining a cornfield, and she was in the habit of jumping out of her pasture into the cornfield at night. True to her instinct, after the total eclipse she was found enjoying herself among the corn. During the most exciting period of the phenomena, General Keifer saw a countryman going at full speed across the field, who said he was going to see what his chickens were doing. He soon returned, in a state of intense disgust, declaring that his chickens scratched away, during the whole time, as if nothing had happened.

Such are the principal phenomena attending this rare and wonderful event. If we could have prolonged the duration to fifteen minutes, we would have bought it at any sacrifice. Oh, if we could have had only time to have sketched, and measured, and studied those wondrous revelations, life would have seemed complete. As it was, it seemed so aggravating, so unsatisfactory, that if another had been visible in California, or South America, or Africa, we would feel full ready to start for it, to complete what was left undone. It has been a most serious difficulty in obtaining valuable observations on total eclipses of the sun, that the observers must, of necessity, be inexperienced, and feel only prepared to make satisfactory observations when the opportunity has passed forever.

When the chronographic records are reduced, it is believed that very accurate and valuable results will be obtained.

The following quantities, measured from the chronograph sheets, will show the progress of the phenomena:—

	Mattoon M. T.			
	H.	M.	S.	
Lunar mountains in contact with Sun	4	11	07·76	H.
Beginning of Eclipse	4	11	17·16	H.
" "			15·50	S.
Red Flame seen	5	10	50·00	H.
Bailey's Beads	5	11	23·8	H.
" "			22·6	S.
Beginning of Total	5	11	28·8	H.
" "			28·3	S.
Duration of Total		2	42·70	H.
" "		2	44·30	S.
Observation with naked eye		2	40·	
Disappearance of Red Flame		5	50·	H.
		after total ended.		
End of Eclipse	6	09	09·70	H.

The initials "H" and "S" refer to the observations of Messrs. Hough and Swift.

Dudley Observatory, August 26th, 1869.

ELECTRICITY IN PLANTS.

By Edwin Smith, M. A.

There is a very interesting chapter in Becquerel's smaller treatise (in three volumes) on "Electricity and Magnetism" concerning the electrical phenomena of plants. I was induced, by reading this chapter, to make a series of experiments, with a view to illustrate the author's statements, and, if possible, to throw some fresh light upon an obscure and puzzling subject. I am now going to put together some notes of these experiments, carefully made at the time, in the hope that they may not be without a certain interest to others. The galvanometer employed is a home-made one, but tolerably sensitive. My greatest difficulty has been to depolarise the slips of platinum by means of which I have made the voltaic circuits; but every care has been taken, to the best of my ability, to obviate error arising from this cause, as well as from thermo-electric disturbance.

Experiment 1.—Take the thick, juicy leaf stalk of the common garden rhubarb, and, having cut off a length of from 4 to 18 inches, apply a square of platinum foil to each end of the piece. Connect by means of platinum wire, these two plates with opposite terminals of the galvanometer. The needle will be powerfully deflected. Now reverse the position of the rhubarb between its platinum surfaces, connect as before, and the needle will again be deflected, but in an opposite direction. Having previously ascertained how to interpret the movements of the needle, by noticing its behaviour when a voltaic current is produced between zinc and diluted acid, with platinum for negative plate, and transmitted through the coil, you will at once conclude that a current of electricity is passing from that end of the leaf stalk nearest the root towards the opposite end, nearest the blade of the leaf.

Experiment 2.—Cut off a piece about 3 inches long from the thickest part of the same leaf-stalk. Divide it longitudinally down the middle. Pare off a level slice of the outer cuticle. Lay the platinum slips close to the two flat sides thus provided, and connect with the galvanometer. There will be indicated a current from the outer side nearest the cuticle to the inner axis of the leaf-stalk. If the section is made thinner, there will be a current in the same direction. You may confirm your conclusion, as before, by simply turning over the piece of rhubarb, so as to reverse the current. Experiments 1 and 2 may be tried upon a thick midrib or branch of the same, taken from the leaf-blade, with a precisely similar result. A cucumber acts in the same way.

Experiment 3.—Insert a platinum wire into the lower end of the flower-stalk of peony. Apply foil to one of the large bracts, or to a petal; connect, and observe deflection. A current is detected flowing from the lower end of the flower-stalk to the bract or petal. The same experiment may be tried with a sprig of fresh oak-leaves, or bramble, or chickweed, or bunch of elder-buds, or poppy-flower, or stalk and leaves of poppy. The current always sets from the point nearest to the root towards the organs furthest from the root. If wires be inserted in the pistil of a flower and its stalk, there will be shown a current flowing towards the former.

Experiment 4.—Lay a leaf of the common dock between pieces of platinum foil. Connect the different surfaces with opposite terminals of the galvanometer, and notice the deflection. A current is indicated from the upper to the under surface of the leaf. A leaf of Spanish chestnut or of young elder will give the same result; but in four experiments on a leaf of sycamore, I got a current from the under to the upper surface, after a momentary current in an opposite direction. I infer, however, that the momentary current was the true one, and that the second arose from polarisation; for I obtained this latter current by merely employing filter-paper dipped in distilled water, and laid between the slips of foil.

Experiment 5.—Twist a piece of wire round the outer cuticle of a young twig of hawthorn. Insert a second wire between the bark and wood, so as to touch the layer of cambium. On completing the circuit, a current will be indicated from the cambium to the outer cuticle. Again: pass a wire into the pith, and a current may be detected taking a direction from the cambium to the pith. Instead of hawthorn, a cutting from a fresh branch of elder, laurel, hedge-mustard, thistle, groundsel, yarrow or other dicotyledonous plant, may be employed, with, as I have uniformly found, the same effect.

Experiment 6.—Scrape off the outer cuticle of the root of cress. By means of wires, as before, test the direction of the electric currents. They will be found to flow from the outside to the axis of the root, and again, from the root-stock, or point of junction with the stem, towards the lower tapering end. The same effects are exhibited by the root of cat's ear, or of thistle. If plates of platinum foil are applied to the flat surfaces made by cutting across the thick and thin ends of a carrot, a current will be found to set from the thick end of this root to the smaller end.

Experiment 7.—Take a bunch of the seeds of sycamore. Dip a samara attached to the stalk near its broader end into one of the mercury cups, and a samara attached to the stalk at a point nearer the smaller end into the other cup. A current is indicated from the former towards the latter, in strict analogy to what happened in the third experiment. Or a piece of the stalk itself may be bent, and its ends dipped into the mercury-cups. A current will be indicated, having the same direction as before. A cutting from any pliable stem may be tried in this way, and always, so far as my experience goes, with a similar result.

Experiment 8.—Pass a platinum wire through the tubular hollow of a stem of *Poa*, or some other meadow grass. Twist another platinum wire round the outside, and connect both with the galvanometer. A current will be shown, having a direction from the interior to the exterior surface of the stem in question. Such appears to be the law with the stems of monocotyledonous plants.

Experiment 9.—Make two cuts through a raw potato, one through the centre, another near the outer coat. Apply strips of platinum to the two flat surfaces, and connect with opposite terminals of the galvanometer. A current is shown to be passing from the centre towards the outside. A lemon, treated in the same way, furnished a current from the outside towards the centre. With a turnip, a gooseberry, and a pear, the same result was obtained ; but a stalk of asparagus followed the law of the potato. A boiled potato, tested, when cold, by the same method, gave a current from the outside towards the centre, the indications being confirmed by a reversal of the slice between the platinum conductors. But, after moistening a fresh piece of boiled potato with distilled water, a current was obtained from the centre towards the outside—a result confirmed by reversing the position of the slice between the platinum conductors, as in the previous trial. Fresh platinum was employed, to obviate, as far as possible, any error from polarisation.

Experiment 10.—Reduce to a pulp, with distilled water, some of the meal nearest the coat of a baked potato. Then make a similar pulp of some of the meal at the centre. Having placed a plug of tow at the bend of a U-tube, pour the pulps thus prepared into different limbs. Connect, by slips and wires of platinum, with the galvanometer. In my experiment, a current was indicated from the outer pulp towards the inner pulp, agreeably to the result of my first experiment with a slice of boiled potato. My object was to destroy all vitality in the tuber by boiling or baking, and to see whether any chemical action might still remain—sufficient to cause a voltaic current when meal from different parts of the potato was made to furnish a voltaic couple.

Experiment 11.—Having procured a garden nasturtium growing in a flower-pot, insert a wire in the fleshy stem, a few inches above the soil. Then thrust a second wire through the small hole at the bottom of the pot into the soil. Connect with galvanometer. The needle is so deflected as to indicate the passing of a current from the plant to the soil in which it grows. Watering the soil made no change in the direction of the current when I performed the experiment. I also stuck the first wire into the stem in various ways and in various parts, always with the same results. At the same time, a current was detected passing from the root end towards the leaf end of the stem, conformably to the rule in other cases.

Experiment 12.—Make a solution of oxygen in distilled water, also a solution of carbonic acid. Pour them into the different limbs of a U-tube furnished with a plug of tow. Insert platinum slips, and connect with galvanometer. There will be a marked deflection of the needle, showing the passage of an electric current from the oxygen to the carbonic acid. Confirm the result by reversing the platinum connectors.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, December 15th, 1869

The meeting was called to order with the President, Mr. J. Vaughan Merrick in the chair.

The minutes of the last meeting were read and approved.

The actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting held December 8th, 1869, the resignations of membership in the Board by Messrs. James Dougherty and O. Howard Wilson were accepted; also, that donations to the Library were received from the Chemical Society, the Institution of Civil engineers, and the Society of Arts, London; l'Academie des Sciences, Paris, et la Société Industrielle, Mulhouse, France; Frederick Emmerick, Esq., Washington, D. C., and Miss Eliza S. Quincy, Boston, Massachusetts. A paper on Areonautic Navigation was then read by Mr. John Wise, in which the prevailing direction of the upper air currents, as derived from his experience in 400 voyages, were described, and the possibility of employing them for purposes of air-sailing or drifting was discussed. The Resident Secretary then read his report on Novelties in Science and the Mechanic Arts.

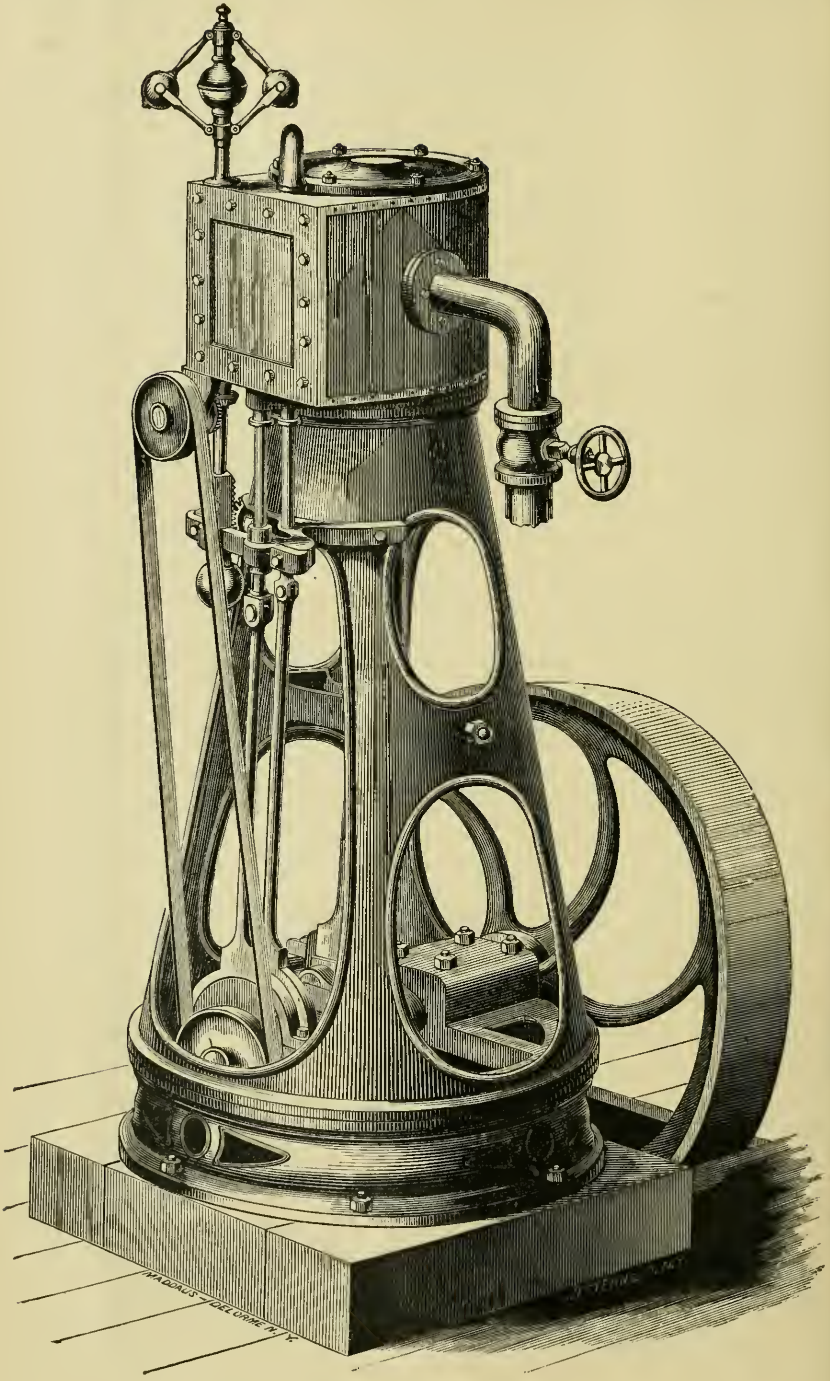
On motion of B. H. Moore, Esq., nominations were made for officers and managers to serve the ensuing year.

Mr. J. Vaughan Merrick, having been renominated for President, returned his thanks for the honor, of which he was deeply sensible; but stated his intention to withdraw his name as a candidate for election, believing that the interests of the Institute would be promoted by occasional changes of its Presiding Officer. Such changes would serve to infuse vitality and energy into its proceedings. Having occupied his position three years, he would, therefore, nominate for the office Mr. Coleman Sellers. Nominations were then made for the other officers and members of the Board of Managers.

Judges of Election—Wm. A. Rollin, C. S. Bement, Theodore D. Rand, Hector Orr, M. W. Haines, Raper Haskins, Geo. Gardom.

The meeting was then, on motion, adjourned.

Henry Morton, *Secretary.*


MADDAUS—DELORME N.Y.

THE RIDER VERTICAL ENGINE.

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VOL. LIX.] FEBRUARY, 1870. [NO. 2.

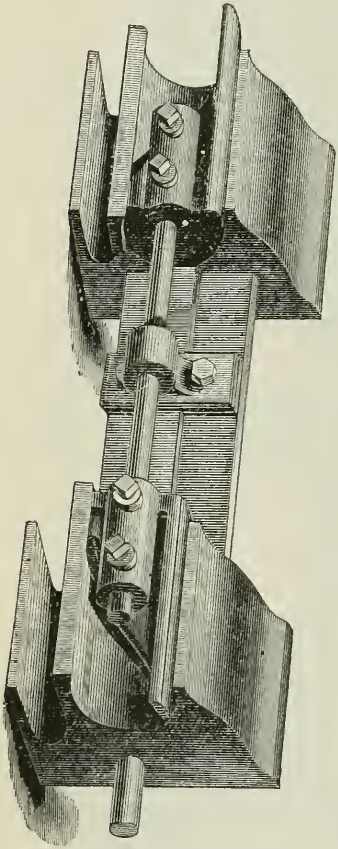
EDITORIAL.

ITEMS AND NOVELTIES.

The Rider Vertical Engine and Valve.—The opposite plate exhibits the Rider Vertical Engine, which possesses many advantages as regards compactness, solidity and economy, but whose chief peculiarity is found in its automatic cut-off valve, of which we will give a brief explanation with the aid of the subjoined cut.

In short stroke engines, where the ordinary three-port valve is generally in use, the main slide valve is, in its action, and in the form of its face side, similar to that of the well known slide valve, with the exception that its ends are lengthened to admit of steam ports or openings being formed outside of the valve proper. These openings or ports are, *on the face side of the valve*, rectilinear and rectangular to the motion of the valve, that is, they run parallel with the ports in the cylinder or disposed *square* across the valve seat. On the *back* of this main valve, where the cut-off valve is fitted, these steam ports are *oblique*, and at opposite angles to each other, the use of which will be presently explained.

The cut off valve is a sector of a cylinder, with its ends cut off obliquely in opposite directions; so that the extremities or acting ends of the cut-off valve respectively conform to the lines of a right and left hand screw of high pitch, corresponding to the obliquity or angle of the steam ports in the back of the main slide valve.



This cut-off valve just described is fitted into a semi-cylindrical recess in the back of the main slide valve, and between the spiral openings. It is operated lengthways by a separate eccentric, to which it is attached in the usual manner, excepting that it has a swivel joint to permit its partial rotation. A portion of the valve stem is made square, or sometimes arranged with a "feather" and at this place, on the valve stem, is fitted a sector, engaging a rack on the lower portion of the governor spindle, so that as the governor rises or falls, the cut-off valve will partly rotate. Thus the cut-off valve is moved lengthways by the eccentric, and, at the same time, has imparted to it, by the governor, an adjusting motion on its axis.

As a consequence of the radial motion imparted by the governor, and the spiral form of the steam ports and acting ends of the cut-off valve, the distance between the openings and the ends of the valve is varied within very wide limits, the effect being to cut off the steam at any point of the stroke. The arrangement may be compared to a right and left hand screw, formed by the shape of the valve ends and the openings.

This device is extremely sensitive to the action of the governor, as the rectilinear motion by the eccentric causes the radial or axial movement of the cut-off valve to be effected by the least possible amount of force. This compound motion also highly favors the perfection and durability of the surface. In engines of a larger size, where it is desirable to have short steam passages, the main and cut-off valves are divided through the centre, and each end carried outwards to act on the steam ports of the cylinder at its ends, as is usual with the ordinary slide valves as commonly constructed.

Saint Louis Bridge—Use of Calcium Lights.—From Mr. W. Milnor Roberts, who is in charge of the work, we hear that the immense caisson 82 by 60 feet is now at a depth of 60 feet (January 31st) or 35 feet above the rock, and has been making an average progress of 8 inches a day.

The air pressure corresponding to the present depth is 25 lbs. per square inch. It will be remembered that the masonry is laid on these caissons as they descend. When this work is carried on at night a lime light has been employed with satisfactory results.

By advices of a still later date received at St. Louis, by telegraph, from the caisson with which the St. Louis office of the Company is now in direct connection, we hear that the depth reached is 68 feet and the progress about 13 inches per day.

February 24, 1870. In a letter lately received from Mr. Roberts, we have the following further particulars.

"Our east or deep pier, this morning, was sunk 71¼ feet below the surface of the water, and was 22¾ feet from the rock, going down a foot or more per day.

"Our west pier (begun January 15th) was sunk 27 feet below the surface of the river, and was 39 feet from the rock—going down a foot or more per day. The west pier is about 28 feet less in depth from the surface to the rock than the east pier. The river at present is about 8 feet above extreme low water mark.

"Early in March we hope to be down to the rock with the deep pier, if we are not delayed with the stone.

"We have used calcium lights only for our open air work in laying masonry on the top of our caissons. One light on one side and one at the other, on diagonal corners. We found that they distributed the best light when thus placed. We had the oxygen gas forced into copper gasometers with a pressure of about 200 lbs. to the square inch. These were carried over from the city to the piers on a little steamer, and the gas was conveyed to the burner through small lead pipe. At first our reflectors were of glass, but so many become broken that they were changed to metal. A man remained with the two burners through the night to regulate them occasionally, and to mend the pipes when a burst would occur. They usually burned from eleven to twelve hours, and with the aid of some movable large reflector lamps, the masons worked as well at night as in the day. The cost of the calcium lights, to our company was $3·75 per hour, each."

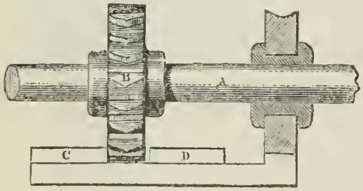
Converting Rectilinear into Intermittent Circular Motion, by William M. Henderson, C. E., of Philadelphia.—We represent in the adjacent woodcut this contrivance which admits of numerous and varied applications, as may be easily seen on inspection. Its construction is as follows:

Upon the drill-stock A is secured a toothed wheel, B, one side of the teeth of which is formed with a double-inclined surface, while the other sides of the teeth may be parallel to each other as shown.

Tangent to the teeth of this switching-wheel is a plate, with double frogs, C D, so arranged, in reference to the teeth of the wheel, that upon motion being given to the drill-stock, say in a horizontal direction, C will cause a partial turn of the wheel to the right.

When the return stroke is being made, the other frog D, will encounter the opposite point of the same tooth, and complete the movement of the wheel, still in the same direction.

It will be observed this second movement brings a new tooth in position to be operated upon by the first frog C, which then throws this new tooth forward in position to be acted upon by the second frog D, which, continuing the motion of the wheel, rotation will be carried on *ad infinitum*, as long as the drill-stock is reciprocated.



The same effect will be produced upon the wheel if the frog-plate is reciprocated instead of the drill-stock.

The point where the turning is effected can be arranged to occur at the middle, or any part of the stroke desired. It will, at the same time, be observed that in all other positions, except where the turning does occur, the wheel, and consequently the drill-stock, are firmly held from turning by the teeth of the wheel locking on the straight part of the frogs.

The relative position of these frogs, in reference to the teeth of the wheel, is not an arbitrary matter. They may be placed on opposite sides of the wheel, or may be made to act in conjunction with any particular teeth upon the circumference.

Other modifications of this principle of converting rectilinear into intermittent circular motion may be substituted for the plan herein described, as, for instance, the frogs may be arranged on the inner circumference of a drum, enveloping the toothed wheel, in which case the drum can be made to revolve around the wheel, or the wheel within the drum, by the locking of the one or the other, as may be desired; or instead of teeth, the wheel may be pierced with angle-holes, while the necessary motion may be obtained by pointed spikes, equivalents which will effect precisely the same results.

This combination may be used to produce an intermittent rotary feed motion in a spindle or shaft, such as a drill-stock for mining-operations, as applied to rock or coal drilling machines, feed-bars for planing-machines, clock-work escapement, paper cutting and ruling machines, and others, where an intermittent feed-motion is required, such as is given by the well-known ratchet and pawl device, which device, owing to certain inherent peculiarities, cannot always be applied to advantage.

Creeping of Clay. Anchor-Ice.—We have just read, with great interest, the eighth annual report of the Board of Public Works of Chicago, published by Jameson & Morse, Chicago.

The Board of Public Works of the city of Chicago is a thoroughly organized body. They have under their immediate care the construction and improvement of streets, the sewage system, the supply of water to the citizens, and the construction of bridges over and tunnels under the Chicago River. At present they also have in charge the deepening of the Michigan and Illinois Canal for the purpose of improving the sanitary condition of Chicago River. Their proceedings in these matters have been fully set forth, for the year ending March 31st, 1869, in their eighth annual report. The report shows that they expended over $2,000,000 for street improvements; for river improvement over $537,000, and for water fund over $696,000.

The most voluminous and interesting part of the report is that of the city engineer, E. S. Chesbrough. And the most interesting part of his report is that which gives a description of the Washington Street Tunnel under Chicago River, and of the Lake Tunnel under Lake Michigan, both of which are accompanied by several cuts of the works.

All the important facts about the contracts, the process of construction, the difficulties encountered, and the manner of overcoming them are fully set forth.

Two interesting facts are here noticed. The east end of the tunnel was completed to the centre of the river and closed up, and the water let into that part of the river. The west end was then made. Before the two parts were joined a leak was observed in the east part, which, at first, was supposed to be due to the dragging of an anchor over it, but, afterwards, it was found to be due to a longitudinal movement of a part of the tunnel. This was caused by the *creeping* of the clay surrounding the masonry. At the end of the east part, where it terminated under the river, the clay was practically unsupported, and the body of earth in the vicinity tended to creep or move towards that point. This creeping movement of masses of clay is often very troublesome and must be strongly guarded against, especially in subterraneous works. Since the construction of the under-ground railroad in London it has been observed that the foundations of buildings, many feet distant, have been so weakened as to cause serious apprehensions for the safety of the structures. The cause is supposed to be due to the movement of the sub-soil towards the subterraneous passage.

The other fact is, that the lake shaft of the Lake Tunnel was so filled, at one time, with anchor-ice, as to completely shut off the water from the city. The whole city was without a supply of water for three hours. The city has no reservoir for storing water, but simply several small ones which furnish a head for distribution, so that if the pumping engines should be disabled or the supply of water through the tunnel be cut off, as in this case, the supply which is in the small reservoirs and in the water pipes will be very soon exhausted.

The formation, or at least, the collection of anchor-ice about the entrance of water pipes is a troublesome feature, but it has been encountered before. The readers of the *Journal** will recall the in-

*See vol. LV. p. 212, where the theory and mode of prevention are discussed—(Ed.)

teresting case which occurred a few years since at the Detroit Water Works, but the case at Chicago is more important, because the stoppage of the entrance of the tunnel for a few hours only, would prove, not only inconvenient, but in case of fire might be fatal to many material interests. It is evidently desirable that the cause be removed or that the overseer should be able to remove the obstruction promptly. D. V. W.

Economy of Steel Rails.—The following calculations exhibit very clearly the great economy of using hammered steel rails on all roads which have so heavy a traffic that four years will fairly represent the average life of the best unhammered iron rails. The cost of re-rolling is estimated at $30·00 per ton, and the loss, at each renewal, from wear of iron, expense of taking up and relaying, and other contingencies at $15·00 per ton.

Duration of Steel Rails	20 years.	40 years.	60 years.
Cost of Best Hammered Steel Rails	110 00	110 00	110 00
Compound interest at 6 per cent	242 79	1,021 43	3,518 64
Total Cost of Steel Rails	352 79	1,131 43	3,628 64
Cost of Iron Rails	76 00	76 00	76 00
Compound Interest	167 73	705 71	2,431 06
Expense of re-rolling	180 00	405 00	630 00
Compound interest	153 41	1,141 98	4.809 09
Total Cost of Iron Rails	577 14	2,328 69	7,946 15
Deduct Cost of Steel Rails	352 79	1,131 43	3,628 64
Saving, per ton by using Steel	224 35	1,197 26	4,317 51
Present worth of Saving	69 95	116 40	130 88
Present Saving per mile	6,995 00	11,640 00	13,088 00
Increase of dividend on a road costing $40,000 per mile	17·49 p. c.	29·10 p. c.	32·72 p. c.

Therefore, if the average life of a steel rail is only 20 years (= 5 iron rails), it is as cheap to lay steel rails as to lay the best iron rails at a cost of $6·05 per ton ($76·00 — 69·95 = 6·05).

If the life of steel is 40 years (= 10 iron rails), which is probably a moderate estimate, a saving of $4,040·00 per mile could be made by laying steel, *even if the best iron rails were offered as a gift.*

If the life of steel is 60 years (= 15 iron rails), an estimate which is more than justified by the experience of the Pennsylvania, the Philadelphia, Wilmington and Baltimore and other railroads, and by a long series of experiments at home and abroad, the saving effected, by laying the whole road in steel, would be sufficient to add nearly 2 per cent to the annual dividends, on a road which could pay 6 per cent. with a track of the best iron rails.

On roads with a lighter traffic, the saving is still an important consideration. If, for example, the life of an iron rail, is 10 years, and a steel rail will only wear out five iron rails, the present worth of the saving by the use of steel is $17·37 per ton, which makes steel rails at $110·00 as cheap as the best iron rails would be at $58·63 per ton.

Even allowing 8 per cent. compound interest for the use of money, it would be cheaper to buy steel rails that would wear out in 20 years than to pay $22·00 for iron rails that would require re-rolling in 4 years.

The great increase of saving on curves or grades, in yards, and in other places where the wear is so great that the life of the best iron rails is two years or less, is shown in the following table, which is computed at the prices now ruling ($110·00 per ton for best steel, and $76·00 for best iron), allowing 6 per cent. compound interest.

Present Worth of Saving on 100 Tons (about 1 Mile) of Steel Rails.

When Iron Rails Wear........	2 years.	1 year.	6 Months.	3 Months.
If 1 steel equals 3 iron rails...........	$4,169·41	$4,850·13	$5,210·61	$5,401·48
If 1 steel equals 5 iron rails...........	10,165 08	12,192·99	13,326·95	13,944·73
If 1 steel equals 10 iron rails..........	20,252·52	27,207 60	31,637·49	34,222·33
If 1 steel equals 15 iron rails..........	25,885·30	38,427·41	47,027·31	53,045·19
If 1 steel equals 20 iron rails..........	29,030·62	46,811·59	61,057·10	70,417 07

There are some roads of heavy traffic, but only a few, which claim that they can get a year's average service for the best iron rails, where the wear is most severe. The above table shows, that, by substituting a steel rail which would wear only five years, they could effect a saving which would be equivalent to an immediate addition to their capital of $121·93 on every ton, or $12,192 99 on every mile of steel laid down. In the extreme case supposed, when the life of an iron rail would be only three months, and the life of a steel rail five years, the saving would be $70,437·07 per mile.

Self Oiling Journal Bearing, for Railroad Cars and other Machinery—By J. P. Wendell—This invention consists of a journal bearing which can be adapted to any form of box. It is cast with an oil chamber in its mass communicating with several circular openings on opposite sides of the face of the bearing, which openings are completely filled by pads of asbestos, black lead and paper pulp (or other porous material) which receive a graduated supply of oil from the chamber through smaller openings, and distribute the same constantly upon the metal surface when in motion. There are also two small openings in the centre of the face, into each of which a wick is fitted connecting with the oil reservoir; and either class of these openings has been found to furnish sufficient lubrication for service.—Cut No. 1 shows a top view of bearing. No. 2 shows a face view of bearing, and No. 3 gives a sectional view of same.

Fig. 1.

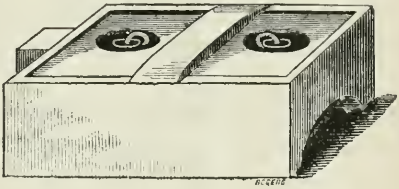
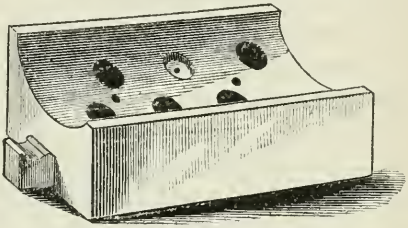


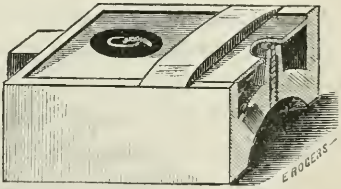
Fig. 2.



The bearing is now cast in brass, but may be made of other material if preferred, it has been tested by several prominent Railroads, all reporting favorable results.

One set of the bearings (taken indifferently from a lot) was used on the *Pennsylvania Central Railroad* for one hundred days, running eighty miles per day (making a service of eight thousand miles) and oiled every two weeks. Each chamber holds but four fluid ounces and at each time of inspection the former charge was not exhausted. The words of the Superintendent are—" There was no sign of heating of the journals, and the bear-

Fig. 3.



ings were in as good condition as when put in—no packing was used or required."

The above bearings are still in use on this road and with the same good effect.

The Broadway Pneumatic Railway.—We lately enjoyed the pleasure of a promenade in connection with Broadway, different from that celebrated in song, this being, not only down, but under Broadway. We passed, in fact, on that occasion, through the tunnel, as far as completed, of the Beech Pneumatic Transit Company. This tunnel, which is about eight feet, starts on Warren Street at the corner of Broadway, and by a curve of wide sweep passes under the centre of the renowned highway, down which it proceeds in a perfectly straight line. The curved portion is lined with an ingeniously combined sheathing of iron segments, the straight portion forms a continuous cylinder of brick work; brightly illuminated at the outset by glass lights in the pavements, and further on by a continuous series of gas lights. This tunnel quite fails to impress us with the idea of its *subterranean* character. A partly finished passenger car, of elegant construction, stood upon the track, which supported on curved iron cross-ties, runs through the entire length of the excavation, and with its commodious seats and prettily finished wood-work presented a most inviting appearance. The outline of the car, like that of the tunnel, is cylindrical, the wheels being placed under the seats, and the heighth in the middle being about 7 feet, the accommodation in entering and going out is all that could be required. Passing to the end of the excavation we next examined the means by which the work was carried on. These means we will endeavor briefly to describe. A cylinder of boiler plate some 12 feet long and of the same diameter as the tunnel, including the brick lining, is provided, at its rear end, with a strong ring of cast iron to which are attached eighteen small hydraulic rams, each capable of exerting a force of seven tons, and bearing upon another similar ring of cast iron abutting on part of the tunnel already finished. These rams are all connected with one driving pump, but are individually controlled by stop-cocks. The pump, then being worked, the iron cylinder is pushed forward like a saddler's punch through leather, or a wad cutter through card. If, by reason of unequal resistance, it tends to go crooked, some of the presses on the advancing side are shut off and the direction is thus regulated. Besides the forward portion of this cylinder already described, there is a short piece reaching some eighteen inches back of the heavy ring. When then the cylinder has been pushed forward a certain distance, the hydraulic rams are closed up, the rear ring is pushed forward and a course of brick-work is added to the tunnel lining inside of the rearward projecting cylinder. At the next forward motion of the same, this new ring of brick-work is exposed and the earth around settles against it by the thickness of the cylinder which is $\frac{3}{16}$ of an inch. To prevent the caving in of loose materials in front a number of horizontal shelves are set across the forward part of the cylinder. Thus the excavation and building are carried on simultaneously without a moment's exposure of any portion of surface without support. In the basement of the building were to be seen, amid masses of excavated boulders, bricks, mortar and various material and debris, the massive members of machinery to be used in supplying the air blasts by which the cars and their passengers are to be wafted through the subterranean corridor. At a subsequent period we hope to furnish our readers with detailed illustrations of this interesting work, which is being carried on under the direction of Mr. A. Beech, President, M. S. Beech, Treasurer, Joseph Dixon, Secretary, Charles K. Graham, Consulting Engineer.

Explosion of Fulminating Gold.—We are indebted to Mr. William A. Street, for the following details of a curious explosion which lately occurred at a jewelers establishment in Syracuse. A quantity of gold scrap had been dissolved in nitric acid and precipitated by ammonia. The entire material being then placed over a register to evaporate was left there, in an earthen jar, until dried. It was then removed, and when cool, the operator, who had evidently not studied the chemistry of gold, proceeded to scrape out the dry precipitate into a sheet of paper; a serious detonation soon occurred and pieces of the jar were driven through a thick plate glass screen, making clear holes, without cracks, so high was their velocity. We are not told what became of the operator but fear the worst. It is almost superfluous to add, that if, as is probable, an excess of ammonia was added in precipitating the gold, the entire process was exactly that given in most chemical works for producing fulminating gold in its most explosive condition.

Viaduct Over the River Tees.—This Viaduct, is intended to carry the Merrybent and Darlington Railway over the river Tees, near the village of Cleasby, in the county of York. It is being constructed by Messrs. Hopkins, Gilkes and Company, of Middlesbrough, for Messrs. Lovel and Jones, the contractors for the line, from the designs of Messrs. Nimmo and Mackey, Westminster, the engineers to the Company. It consists of three river openings of 75 feet clear span, with two land arches in the abutments. It is constructed for a single line of railway, and is 15 feet wide between the parapets. The piers in the river consist each of two cast iron cylinders 8 feet apart from centre to centre, and 6 feet 6 inches diameter up to the level of the bed of the river, at which point they are gradually contracted, in a distance of 3 feet to a diameter of 5 feet. These cylinders are cast in 8 feet lengths, and are braced together near the top by a cast iron frame, accurately fitted and bolted to each cylinder. They are filled with concrete to the level of the bed of the river, and above this they are built in with solid brick work, and terminate at the level of the girder-beds by an ornamental corner of ashlar, on which the girders rest. Owing to the nature of the strata it was found necessary to sink these cylinders by means of a pneumatic apparatus to the rock which underlies the bed of the river at a depth of 30 feet. The abutments are built of solid masonry with brick arches.

The superstructure consists of two sets of main lattice girders each 80 feet in length and 8 feet in depth. These girders are placed 8 feet apart with transverse beams of timber 12 inches × 9 inches laid at distances of 3 feet 3 inches, and projecting 3 feet 6 inches beyond the side of the girders.

New Magnesia Burner.—During a visit which we lately made to the works of the New York Oxygen Gas Co., 547 west 41st Street, we saw a new burner in operation which had just been received from France, and which successfully meets the difficulty previously found in burning the oxygen light, with a very low pressure on the "burning-gas." Each elementary burner consists of three very minute jets, two at either side coming somewhat towards each other which are supplied with the ordinary gas, and the other between them, and a little shorter, which is fed with oxygen. By this means, no matter how low the pressure on the illuminating-gas may be, no retreat of the flame into the jet can occur. We saw this burner, in fact, operating most excellently with a pressure of about $\frac{2}{10}$ inch of water. We hear from Mr. C. H. Stoddard, that a yet further improvement is announced, of which specimens will soon be on hand.

Editorial Correspondence.

NICKEL LINNÆITE.

Geological Cabinet General Land Office.
Washington, D. C., January 20, 1870.

Editor of the Journal of the Franklin Institute.

SIR:—The valuable metal, Nickel, now employed extensively in preparing various alloys resembling silver for table use, and in making the coins of the United States and other countries, has been but seldom found in this country. In small, but not paying quantities, there are several localities of it, and the only one which promises to yield it in abundance is the deposit at mine La Motte, Missouri, so celebrated already for its copper, lead, iron, and other ores. A specimen of Nickel-Linnæite or Siegenite has been received at the Geological and Mineralogical Cabinet of the General Land Office, yielding over 30 per cent. of nickel. Nickel was discovered in 1751 by Cronstedt, in Sweden. It is a metal of a color not much differing from that of silver, it is magnetic, soft and malleable, may be forged, rolled, bored, drawn into wire, &c. It is more tenacious than iron, and less subject to oxydation than silver. In the year 1824 (the statement may yet be found in Thenard's *Traite de Chemie*) it was stated that the metal nickel could not be put to any use. However, it was long before this, that Nickel was employed by the Chinese for the preparation of an alloy termed by them "Packfong" and although in 1776 Englestroem had analyzed this composition, no practical application of this metal was made for some time.

The separation of nickel from its ores is exceedingly difficult and complicated. The crude material is the cobalt speise and the mat obtained in lead and copper smelting works. In order to free this material from arsenic and sulphur it is first finely pulverized and roasted with pulverized coal. The residue is dissolved in muriatic acid, and the solution diluted with much water in order to separate the bismuth. If the liquid is now mixed with hypochlorite of lime, the iron is oxydized to a proxide, when it may be precipitated with the arsenic acid existing in the liquid. If the liquid is to be freed from copper a current of hydrogen is conveyed through the same, and having separated the precipitate produced, the cobalt is thrown down by hypochlorite of lime. Now the nickel may be separated with milk of lime. In subjecting the precipitate with carbon to a red heat the metal may be obtained in its pure state. The manufacture of "Packfong," in Europe, is not of a very old date. This term is synonymous with argentum, german silver, British plate. Its composition varies considerably as may be seen from the following table.

	1.	2.	3.	4.	5.	6.
Copper......	88·	65·0	43·8	40·4	55·	50·
Nickel.........	8·75	16·8	15·6	31·6	20·	25·
Zinc..........................	.....	13·0	40·6	25·4	25·	25·
Iron.......................	1·75	3·4	......	2·6	......	...
	98·5	98·2	100·	100·	100·	100

It may be seen from this that an alloy may be made with less than ten per cent. of nickel, but the wearing quality of the metal is decidedly injured by two great a reduction in the quality of nickel. I will remark that No. 1 is the so called "white copper," made in Suhl, Germany, a century ago, with copper ores containing nickel, and analyzed by Brandes. No. 2 is an alloy made at Paris, which is capable of receiving a fine polish or gilding. No. 3 and 4 are Chinese packfong. No. 5 is an alloy as used for knife handles. No 6 is adapted for forks. The nickel coins of Switzerland, which have been in use in that country since 1850, consist of an alloy of nickel, copper, zinc and silver. The proportion of nickel and zinc in the 20, 10 and 5 centimes pieces is 1·25, while the amount of copper increases with the decreasing value of the coin. The quantity of silver, on the other hand, decreases with the smaller value. The United States coins, now in general circulation, contain 88 per cent. of copper, and 12 per cent. of nickel.

Very respectfully, A. R. ROESSLER,
Geologist, General Land Office.

New York, February 14, 1870.

Editor Journal of the Franklin Institute.

The record of performances of a number of engines by Wm. H. G. West, engineer, U. S. N., published in the January number, is of much interest, but it occurs to me, the results there given would be much enhanced in value, if Mr. West would give the formula for the horse-power, at which his results were deduced, together with the following elements.

1. If the friction of load, &c., was taken in any other case than that of the U. S. Steamer, Wamponoag?

2. What was the friction of the load computed at, and why is it referred to in one case only?

3. Has the Wamponoag a surface condenser?

4. Has the Ammonoosac a surface condenser?

Respectfully, CHARLES H. HASWELL.

U. S. General Land Office, Cabinet of Practical Geology and Mining.
Washington, D. C, *February* 7, 1870.

Editor Journal of the Franklin Institute.

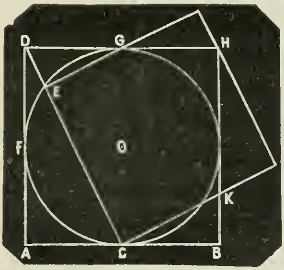
SIR:—It will be remembered that an exposition of the agriculture, manufacturing and mineral resources of California was held last year at San Francisco, at which were exhibited the unmistakable evidence of the existence of the metal tin in California. Sacks of ore, bars of tin plate, of the heaviest quality, and utensils of every sort for domestic use which were manufactured from it, were there collected. There were many who doubted and shook their heads at this display of a long desired but unusual manifestation of riches. The days of humbug were not yet over. Gold and silver, quicksilver and platinum, and many other more common metals in any quantity, they should believe in, but the metal tin, so valuable and found in so few localities in the world, was a demand on their credulity not to be honored. This uncertainty has become, not a dead, but a living certainty. Additional information and additional specimens of ore have been forwarded to this office, and an average sample of the same has been submitted for analysis to the able and distinguished chemist and mineralogist Dr. F. A. Genth, who reports that it contains 13·37 per cent. of Tin. The black mineral in the ore is Tourmaline (it contains Boracic acid) and the brownish red is the casiterite. It is a highly interesting occurence, and the yield of tin is almost twice as much as the usual working ores of the tin mines of Cornwall, England. The property is said to consist of fifty thousand acres of mining lands, and over twenty openings have been effected, from all of which the ore is extracted. The finding of this important metal in California may be regarded as the last crowning act which was required to place California in advance of all the world for mineral wealth. Respectfully,

A. R. ROESSLER.

APPROXIMATE GRAPHIC METHOD OF SQUARING THE CIRCLE.

Philadelphia, *January* 6, 1869.

Prof. Morton.—Dear Sir:—The following geometrical construction, though very simple and beautiful, may be new to your readers as it is to me. I owe it to the kindness of a Scotch professor.



It enables us, 1st, to graphically *square any circle* to within $\frac{1}{52}$ part of its area (sufficiently near for most practical purposes.)

2d. To increase (exactly) any square, (and hence any rectilinear figure) 25 per cent. its area.

3d. To decrease the same 20 per cent. let A B be the side of a square circumscribed about any circle O. Draw D C to the middle of A B. Then the chord C E will be the side of the square approximately equal the circle, and will be exactly $\frac{4}{5}$ the first square.

The proof is based on the well-known principle "the square of the tangent equals the product of the secant and its extreme segment."

That is $\overline{DF}^2 = DC \times DE$, where radius being known the only unknown quantity is D E, which thence equals $\frac{R}{\sqrt{5}}$

Thence $\overline{CE}^2$ is found to be $(3\frac{2}{10})R^2$, while the circle is $(3{\cdot}14+)R^2$, and the square on A B $(4)R^2$.

Another curious and useful result is that the sides of the second square are divided at C, H and K into $\frac{1}{2}$, $\frac{1}{4}$ and $\frac{3}{8}$ parts respectively, which fact enables us to enlarge a square $\frac{1}{4}$ its area without the use of the circle.

Also as $BK = \frac{1}{2}CB$ and C is the middle of, we have the means of reducing a square $\frac{1}{5}$ its area without the use of the circle.

Yours, truly, D. D. WILLARD.

Civil and Mechanical Engineering.

HOUSE MOVING IN BOSTON.

AMONG the editorial notices at the beginning of our Vol. LVII., mention was made of the very extensive topographical changes lately executed in the above named region, and we now extract from a foreign contemporary the following additional items of interest:

"Some years ago the Boston City Authorities, in pursuance of a plan for widening and straightening some of the streets of that city, determined to widen Tremont Street to 60 feet, which necessitated the cutting off or removal of Hotel Pelham. Estimates were made of the damages in both cases, and it was found that removal would be the cheaper, but there were doubts of its feasibility. Experts were consulted, and experiments made, and finally it was determined to move the building, an agreement being made by which the owner gave the city the right to move it back to the new line of the street, the city being responsible for the damage that might occur, and presenting the owner with a deed for the land at the rear, which the building would cover after removal. The work was to be done between May 1 and October 1, 1869. Hotel Pelham is situated at the corner of Tremont and Boyleston Streets, Boston, the fronts on those streets being faced with freestone backed with brickwork, 12 inches to 16 inches thick, and the other walls being of brick. The building was to be moved from east to west, while it contained two brick partition walls running from north to south, and some short partitions extending from Tremont Street to the first of the former partition walls. The side of the building is not at a right angle with the front, but the east and west partitions are at right angles with the side, and therefore not parallel with the front, thus increasing the difficulties of removal. Somewhat irregular in shape, the building covers 5,800 square feet of land, having a frontage of 96 feet on Tremont Street, which narrows to 88 feet at the rear, and a depth of 69 feet on Boyleston Street, while the depth is 62 feet on the other side. There were brakes on both the rear and side. The Boyleston Street front was supported on eight granite columns, 12 feet high; the

Tremont Street front partly on two similar columns, while the remainder was built up of rough block granite, filled in with chipstone, and so poorly constructed that it had to be tied together with iron rods and timbers. Some of the walls were cracked owing to the building having settled after its construction, and paper was pasted over these cracks to see if they increased during the removal; but no change could be discovered. The house is seven stories high above the basement; the total height above the tramways on which it was moved being 96 feet, while its weight was estimated at 5,000 tons, exclusive of the furniture and other articles that remained inside during the removal. The shops and offices on the first floor, and several suites of apartments above, were occupied at the time, the occupants being undisturbed, and the water, gas and other pipes being kept in working order by the use of flexible tubes. The preparations for the removal began June 1, models and plans of the building having previously been made to guide the work. The basement was cleared of all the wooden partition walls, and excavated to the level of the foundations. The building was to be moved westerly about 14 feet, and, accordingly, heavy block granite levelers were laid easterly from each of the walls and brick partitions for a distance of 14 feet, and similar levelers every 4 feet between to receive the walls running north and south as the building progressed. This made four rows of 18 traverses each, all laid solid in cement, thoroughly rammed down to avoid danger from settling, as they bore the great weight passing over. The traverses under the front piers were 6 feet wide, (the piers being 4 and 3 feet wide,) and the others 3 feet wide; while they were sunk 3 feet below the level of the foundations. On the top of the granite a brick wall 20 inches wide, was laid in cement, excepting under the piers, where flagstone and slate were laid. On the top of this iron rails were laid, there being four on each traverse, from 3 to 3½ inches wide, and a ½ inch thick. They were imbedded in cement, and made perfectly level, while 8 rails were laid under the front piers. In addition, under the rough granite wall before mentioned, on the Tremont Street front, there were greased ways to assist its transit.

"The building had to be moved in a straight line with the Boyleston Street wall, and the traverses were, consequently, laid parallel to it. Rollers 1½ inch in diameter were laid 1 inch apart under each wall, and were placed at right angles to Boyleston Street, while a square piece of hard wood was put between each two rollers to act as a guide, and to aid in replacing them when they came out behind as the building moved forward. Over the rollers were placed similar iron rails to those beneath; and over these flagstones, thoroughly wedged with slate and pointed with cement, to bear the weight of the walls above. There was great trouble and danger in getting the traverses and rollers in position under the piers, but it was successfully accomplished. To hold the lower part of the building together as compactly as possible, so that the power, when applied to the exterior, should operate equally on the interior walls, timbers 8 inches square were placed on each side of the walls crossing the line of motion, while over each of the traverses similar timbers were placed in the line of motion and wedged between the others. To prevent the wedging process from spreading the walls iron rods were used to tie the walls together. These arrangements made the lower part of the building perfectly steady. The power was to be applied on the Tremont Street front, and on the exterior of the wall, there a hard pine timber was set about a foot above the rollers, and running the entire length of the building. This was supported partly on a brick wall and party on a frame-work of timber, both of which slipped along on greased ways. An excavation was made, and against the bank wall of the street 3-inch planks were set vertically, and in front of these another heavy timber. Between the timbers were the screws that were to move the building, each of 2 inches diameter and a $\frac{1}{2}$ inch pitch, there being 72 screws required to start the building, while the number was afterwards reduced to 56, which were spread along the 96 feet frontage on Tremont Street. There were used in preparing for the removal over 400 perches of granite, 3,000 feet of flagging, 46,432 pounds of iron, and 49,982 feet of timber. There were 904 rollers, and preparations occupied 2 months and 20 days. Everything being in readiness on the morning of August 21, a man was stationed at every four screws, and 20 men along the lines of the various walls to watch the rollers as they came out, and replace them in front, these changes having to be made every 2 inches that the building moved. At a signal from the superintendent, every man at the screws made one quarter turn, which carried the hotel westward $\frac{1}{8}$th of an inch. The average speed was an inch in five minutes, while the greatest speed was 2 inches in four minutes. The screws were 21 inches long, and it took about one hour and three-quarters to move the length of the screws, when the work had to be suspended to re-arrange the screws and blocking. The first day the house was moved 3 feet, the second day 5 feet, the third day 3 feet 10 inches and the fourth day 2 feet, the whole distance (13 feet 10 inches) being completed on the morning of August 25, while the actual time of moving was 13 hours and forty minutes. After the building was in its destined place the braces and ties were cleared away, the traverses not supporting the walls taken up, and such of the rollers as were loose taken out, while such as were left were firmly cemented as part of the new foundation. The entire cost was $30,000 in currency. Larger buildings have been raised in this country, but never so large a one removed, and thousands of people watched the curious operation."—*Engineering.*

SUPERSTRUCTURE OF THE CHESTNUT STREET BRIDGE.

By Strickland Kneass, C. E.,

Chief Engineer and Surveyor of the City of Philadelphia.

[At page 413, Volume XLIX. of this *Journal* will be found the abstract of a paper read before the Franklin Institute, by Mr. Strickland Kneass, C. E., on the Chestnut Street Bridge, then in course of erection. Since that time, the bridge has been finished and thoroughly tested by a constant and heavy traffic, and we now give from Mr. Kneass' Report to the City, a full account of the superstructure, which was only alluded to in the former paper.—Ed.]

Before entering upon a detailed description of the superstructure, it may not be amiss to allude to some of the cast iron bridges which have been previously erected, for the purpose of showing that in adopting this general plan of bridge, we have not attempted anything new in the principles of construction, or used any material that has not for many years withstood the test of the changes of temperature and the effect of heavy traffic. The first cast-iron bridge erected in England was over the Severn at Colebrook Dale, in the year 1777; it has five arch ribs, with a clear span of 100 feet 6 inches, and a rise of 45 feet, a width of 26 feet, and a sectional area in each rib of 56¼ square inches.

At Buildmas, a bridge with three arch ribs, 130 feet span, with 17 feet rise and width of 18 feet, having a sectional area of 37·5 square inches to each rib, was finished in 1796.

In the same year the *Sunderland Bridge* over the Wear was completed, having six arch ribs, with a span of 236 feet, and rise of 34 feet, and a width of 32 feet, the sectional area of rib being 46·5 square inches.

Bristol, 100 feet span, 15 feet rise, having six arch ribs, and 32 square inches in each, of date 1806.

Bonar, 150 feet span, 20 feet rise, four ribs, and 45 square inches section, of date 1812.

Cauxhall, 78 feet span, 14 feet rise, ten ribs, 1816.

Southwark, 240 feet span, 24 feet rise, having eight ribs, with 214 square inches of section, date of 1818.

Tewkesbury, 170 feet span, 17 feet rise, four ribs, with 36 square inches of section, of date of 1826.

Plymouth, 100 feet span, 14·5 rise, five ribs and 64 square inches section, 1821; and the latest the renewal of the Westminster, with an arch partly of cast and wrought-iron, having 120 feet span, 20 feet rise; are all it is believed in constant use. The widths of these bridges vary from 16 feet to 42 feet, except the Westminster, which is 85 feet.

In France they commenced the use of cast-iron with the "Pont des Arts," with span of 60 feet 8 inches, and versed sine 12 feet, the depth of the arches being but six inches; afterwards the "Pont du Jardin du Roi" was begun in 1800, and finished in 1806, with span of 105 feet and 10 feet rise, having seven ribs, but owing to the high price of iron in France, and therefore a desire to reduce proportions to their minimum with their exceeding high standard of strength of material the French Engineers assumed in making their proportions, none of these bridges were successful, and have either been removed or greatly modified in plan and arrangement. The "Pont de Carrousel" at Paris, 187 feet span, and 15·5 feet rise, a very handsome structure, was built in 1836—has five ribs, with a sectional area to each of 165 square inches, and is therefore proportioned more in accordance with those built by the English Engineers; it is now in full use. In other parts of France there are cast-iron arched bridges of later date which have proved all that their constructions proposed.

In Russia we find the extensive cast-iron bridge built by our townsman, Joseph Harrison, Jr., across the Neva at St. Petersburgh, which, though subjected to the most severe tests of changes in temperature, stands a monument to American professional skill. This bridge has seven spans, with 157 feet as the largest.

The only example in our own country, is the remarkable bridge over Rock Creek, at Washington City, built by a distinguished Philadelphian, Major-General Meigs, U. S. A. This bridge has a clear span of 200 feet, and rise of 20 feet, with a width 26·33 feet, and two supporting arches. The remarkable feature of this bridge is that the arches are cast-iron pipes four feet diameter, through which is brought the entire water supply for the City of Washington. The detail of this structure, in the originality of its double and peculiar adaptation as a viaduct and aqueduct, is most interesting. In designing a bridge to be constructed, I may say, entirely of cast-iron—*i. e.*, where the stability of the structure is dependent entirely upon that material, it is of course essential that it should not be subjected to other than compressive strains, therefore the arch is the proper form, and with a superincumbent roadway so arranged in weight, so as to give, so far as judicious, that inertia to the structure which can only be had to perfection in stone arch bridges. In the structure now to be described, as regards this point, we have obtained very favorable results, as with the constant traffic upon it, and with a large body of men passing over it with a band of music, at cadence step, a tremulous motion sufficient to but slightly disturb the surface of a vessel of water standing upon it was discovered—that this bridge has been constructed with but one pier, may subject it to criticism architecturally, but this arrangement was determined upon for the purpose of causing as little destruction to the river navigation as possible, and placing the pier in such position in the river as to correspond in line with the western pier of the Market street bridge, 500 feet up stream. The width from out to out is 42 feet, with two footways, exclusive of the plinth of the railing of 7 feet 3 inches, and 26 feet of carriage way. Each span is composed of six arches, placed at distances of 8 feet $8\frac{5}{8}$ inches, and 7 feet $10\frac{3}{4}$ inches from centre to centre. They are four feet in depth, and $2\frac{1}{2}$ inches thick, with upper and lower webs of same thickness, and 8 inches wide; thus giving a compressive area of 147·5 square inches to each arch rib. These arches were cast in lengths of 12 feet 10 inches, with end flanches 12 inches wide, having three side-stays from body of segment, and were secured to each other by four screw-bolts $1\frac{3}{4}$ inches in diameter.

The outside arches or ribs are slightly reduced in section, and are cast with ornamental face.

Each rib is footed upon the abutment, and keyed into heavy skewback plates, which are set into granite blocks, 4 feet wide, 4 feet high and 5 feet deep; the iron plate is 4 inches thick, and placed with heavy sheet lead, intervening between the stone and the iron, to correct any irregularities in the stone face. At each junction of arch, rib segment, which are, of necessity, opposite each other, throughout the bridge; the several ribs are tied together with wrought-iron ties of channel iron, 6 inches wide and $\frac{3}{4}$ inches thick, with two inch depth of side rail, and are trussed by a system of intervening cast-iron braces and wrought-iron tie rods; with this arrangement, the vertical position of the ribs are secured.

For the purpose of preserving a true line on the ribs, cruciform cast-iron lateral bracing is introduced, with lengths of 15 feet and 15½ feet, reducing in size from 10 inches at the middle to 6 inches at the segment where they abut, with 1 inch thickness of metal. The system is carried from the abutment to the crown, with two series, and has been found to operate precisely as designed; for in the progress of construction it was requisite that the false works should be so planned as to allow the free and uninterrupted use of the river by the constantly passing tugs with their long line of canal boats in tow. They were therefore subjected to frequent disarrangement of line, from the boats striking the framing; but by the use of the lateral bracing, and wedging at the heel, we could, without the least difficulty, bring our work to the proper line. This was continually occurring, until the key was fixed and our false works were removed.

The upper web of the arch rib, at distances of 4·25 feet horizontal measurement, is increased in width to 12 inches, so as to form a footing for the spandrill castings, which are formed of three cast-iron columns with $\frac{3}{4}$ inch of metal. These castings are each 12 feet 9 inches long, comprising three columns. Those under the roadway extended in elevation only to the under side of the floor beam, to be hereafter described, while the two at the curb line have an increased height, so as to form the curb, dividing the carriage and footway. The outside castings are ornamental in design, and carried up to form a base, to which the side railing is secured. The height of these castings vary from 19 feet 4⅛ inches (interior), to 1 foot 5¼ inches at crown; those at the pier being higher than at abutment by 2 feet 9 inches, so as to give a curved line to the general profile of bridge, which, it is thought, adds much to the general appearance of the structure, as the inclination upon the bridge from each abutment, is tangential to the gradient on the approaches, rising to the pier with an arc of a circle of 4,900 feet radius.

Through these spandrill castings, at about half the distance between the arch and the line of the outer entablature, is carried a strut, adding its mite of strength to the arch, but intended particularly to tie together, and prevent flexure in the columns. This strut, starting at half the height of column at abutment, with a regular curve, disappears in the arch rib at crown. The sizes of the columns gradually decrease with their height, from 8 inches at abutment, to 4 inches at crown. At the foot of each column is a square face, planed to the inclination of the arch; and to facilitate construction, the footings on each casting are in parallel planes, the two outer being in the same plane, and the middle foot differing by versed sine of segment. Each foot is secured with 4 by $1\frac{1}{2}$ inch screw-bolts, with a key notched half into foot and top of rib, so as to relieve any possible lateral strain upon the bolts.

The bracing in the spandrills is arranged with pipe and cruciform diagonals. As before stated, each spandrill casting comprised three of the principal standards or columns, and at the centre column of each of these castings, extending to 4 feet 9 inches from the abutment or pier, is a diagonal brace, with a double series, one above and below the strut before alluded to, as far as the height of the castings permit, beyond which they become single braces. They are tied at the foot of post or top of arch with swivel tie-rods, $1\frac{1}{4}$ inches in diameter, the double lines having an intermediate tie-rod of same diameter at the elevation of the strut rib. All the other columns have the pipe brace, with a rod passing through them, and also the columns, the entire width of the bridge. The pipe braces vary in size from 10 inches diameter at middle and 6 inches at face, bearing against the columns, to 6 and 3 inches near the crown.

The diagonals are cruciform, 6 inches wide, and $\frac{3}{4}$ inch metal, bolted and keyed at top and bottom.

We thus, it is believed, have the main frame of bridge, strutted and tied, so as to prevent any lateral motion or vertical flexure in the main supports of the roadway; and in all cases where a tensile strain is to be resisted, have used wrought-iron, while the cast-iron throughout is subject only to compressive force.

For the carriage-way, there are wrought-iron Phœnix beams laid over each head of column, in length extending from curb to curb. These beams are 9 inches deep, and placed at distances of 4 feet 3 inches from centre to centre. They rest on top of the spandrill posts, in cast-iron chairs, bolted to the spandrill cap as well as the beam. At the curb rib, they are similarly secured on the top of the column, openings in the castings having been made to receive them. They thus perform the double duty of a support to the road-way, and a tie for the upper set of diagonal bracing. The foot-ways are supported in the same manner with beams of wrought-iron 6 inches deep.

For the carriage-way, a ribbed cast-iron arched plate sets upon the floor beams, having an arch of 3¼ inches in its width of 425 feet. Four of these fill the space between the curbs, and are bolted together both transversely and longitudinally. Upon these was placed carefully prepared hydraulic concrete, so as to give an even surface, and prevent water settling in the depressions at the floor beams, or getting at the iron by percolation through the road-way. Upon this was placed a layer of clear screened gravel, 4 inches deep, in and upon which was laid the road-way pavement of cubical granite blocks, 3 inches wide, 8 inches long, and 4½ inches deep, the surface of which was grouted with hydraulic lime water.

A double track city passenger railroad passes over the bridge, track of which is laid with the tram rail, 7 inches wide, on longitudinal stringer and cross-tie, the tie being bedded in bottom layer of concrete. Timber was preferred for this, as it is surrounded with preservatives, and gives a double elasticity to the road-way, the line of rails being not only used by the cars, but by the entire traffic upon the bridge.

The foot-ways are similarly constructed, with flat iron plates, filled with sand, and covered with flag-stone 2 inches thick.

The railing is very heavy, having a top width of 10¾ inches at cap, and a height above foot-way of 3 feet 8 inches, including plinth. The entire work of the interior is painted with a composition of turpentine, lime and coal tar, in proportions of 1 pint of turpentine, 1 lb. quick lime, and 1 gallon of coal tar, which forms a varnish impenetrable to moisture, and durable. The outridge is painted with a tint of Pictou stone, so managed as to throw out the Gothic ornamentation of the outside ribs, spandrills and entablature.

The only provision that has been made for expansion and contraction, is on the railing, which sets in a casing fitted into the lamp pedestal on the abutments and pier, thus allowing free action without showing an open joint, and on the curbs where they connect with the stone at the abutments and pier. All other portions of the structure dependent upon and secured to the arch itself, will accommodate itself to the change of elevation at the crown, without any derangement.

In general design this bridge is of the Ornate Gothic. The outer ribs and spandrills are highly ornamented, the arch having a succession of foliated circles, finishing to a corresponding panel at crown, which is filled with a United States shield. The columns are clustered with appropriate cap and base, and bound together with an ornamental lancet, arches above and below the street. The frieze is a range of rich Gothic arches, with ornamental drops, and surmounted by a richly membered cornice. The railing corresponds in design, having heavy cruciform ballusters, joined by lancet arches, and set upon a full base, and covered with a heavy, moulded cap.

As regards strength of this structure, and treating the arches as built with a succession of vouissors, and performing functions the same as if built of stone, we find that the horizontal pressure at the crown of each road-way rib is, with 100 lbs. per square foot of transient load, 512,585 lbs., equal to 3,475 lbs. per square inch of section, and at skewback, 529,542 lbs., or 3,590 lbs. per square inch of section. Taking the crushing power of best iron at 107,000 lbs. per square inch, the maximum load that would probably be placed upon it, would give a pressure at crown of but $\frac{1}{31}$, its ultimate strength.

The Southwark Bridge, at London, has a horizontal thrust of $\frac{1}{23}$, its ultimate strength, taking the same maximum of the value of cast-iron to resist the compression. As to the expansion and contraction of the main arches, and the consequent rise and fall, on account of the variations of temperature: We have examinations taken at 99 degrees and 12 degrees Fahrenheit, and find the difference of elevation to be $2\frac{5}{16}$ inches, showing a contraction of 0·1107 feet in the length of arch rib, which, for the length of arch, 194·27 feet, taken by measurement, at the first temperature, gives 0·00 1272 feet contraction per degree, or, still further, 0·00000 654 feet per degree per foot of length; thus approximating very closely to the recorded result.

The only material change of plan which has been made in this structure, differing from cast-iron bridges heretofore erected, is the use of wrought-iron for transverse ties for the main arches, instead of cast-iron. I believe, invariably in the foreign bridges, they have placed a heavy, cast-iron plate at each joint of segment of arch rib, extending entirely across the structure, and, as invariably, the tension strain brought upon this plate by the irregular expansion and contraction of the several arches, has broken it, but to no disadvantage as regards the permanency of the structure, as by strapping the severed parts with wrought-iron, the same point is gained which we have to arrive at in original construction.

In the erection of this bridge, it was necessary that there should be no obstruction placed in the river, whereby its free use by the steam tugs would be interfered with, and therefore, a frame work was erected, so as to leave a clear space in middle of each span of 70 feet, which was bridged by Howe trusses 8 feet deep.

The frame work, at abutments, was erected upon piles, giving a firm base; but on each side of pier, a crib was sunk for the bearing of frame, and bridged to pier.

As regards the piles, we had no trouble; but the compressing together of the cribs, although sunk upon rock, being made of round timber, was a most serious annoyance, as requiring constant wedging to keep the rib segments in proper position, both as regards allignment and elevation. Yet, when the key was inserted, and the arches took their bearing, the elevation of crown was within $\frac{3}{8}$ inch of the height intended, and the allignment was correct.

The work upon this bridge was commenced, at the eastern abutment, on the 19th September, 1861, but owing to the increase in cost of material and labor, consequent upon the rebellion, with the delay of litigation, it was not thrown open to public travel until July 4, 1866.

The cost of this structure, as reported to Councils, June 11, 1861, deduced from the detail of proposals and the estimate of quantities prepared at this Department, was $431,424, but the allotment was made conditioned that its cost should not exceed $415,000, as follows:—

Masonry and Approaches,.	$280,433	
Iron Super. and Erecting,...................................	134,577	
		$415,000

The final estimate of masonry, of date September 14, 1866, made up with schedule of prices upon original bid, and quantities of the several kinds of work done, exclusive of a comparatively small sum for extra work—for full completion, amounted to $279,383.

	$279,383 89
The final Estimate of the Superstructure is now ready, and amounts to	134,587 49
Total cost under original contract,	$413,971 38

For the purpose of exhibiting the total amounts actually paid, and also what may be estimated as the entire cost, when all the affairs connected with the bridge erection shall have been settled up, the following statement is given:—

Total cost as before noted,		$413,971 38
Extra work of Masonry, not specified in contract,	$3,865 85	
Advance of prices on Masonry made by Councils, December 10, 1863,	77,116 32	
		$80,982 17
Cost of Bridge as completed,		$494,953 55
Of this amount there has been paid by the Chestnut & Walnut Street Passenger Railroad Company,		$100,000 00
Leaving as a cost to the City,		$394,953 55

It will thus be seen, that had not the condition of the country so changed the basis upon which the contractors made up their bids, as to warrant an increase of the contract prices by the Select and Common Councils of the City, the entire work would have been completed for $417,657.23, or only $2,657.23 over the contract; while if we deduct the amount paid for *extra work*, or work that could not be foreseen in designing a construction of such magnitude, the final estimate would be $1,208.62 less than the contract limit.

BRIDGE CONSTRUCTION, 1869.

Bridge construction has been advancing rapidly during the past year, and principally in the United States. Nature has been kind to American Engineers in giving them great obstacles to overcome, while necessity has rigidly limited outlay; and hence arises a special fertility of invention and a special class of work.

But Holland has been building large Bridges too, and Russia is just commencing on a greater scale than any other European country.

Hitherto her railway bridges have, for the most part, been made of timber, and are to be replaced. Especially on the Nicolai Railway it has been recently decided to reconstruct sixty-eight wooden viaducts—a decision hastened through the destruction of one 1200 feet long by fire. Not much has been done as yet in Hungary, but last year saw the preliminary measures taken for a large amount of heavy bridge work in the future. The great bridge crossing the Hollandch Diep— the Waal and Maas estuary—to join Antwerp and Amsterdam by an unbroken line of railway, is in progress. The contracts for this work was let to Van Vlissengen and Van Heel, of Amsterdam, just at the termination of 1868, for a price of 122,260*l.* The bridge is in fourteen openings of 328 feet each. A main line, undertaken by the State in 1860 for the purpose of connecting Belgium and France with the central part of Holland, has involved in its length the construction of three large bridges within a distance of ten miles, over the Maas, the Lek and the Waal, the two former of which are the channels by which the Rhine reaches the sea, and over which important bridges at Bommel and Crévecœur are in course of erection. The former of these, which is now on the point of completion, consists of eight openings, each of 187 feet, and three of 393 feet 8 inches. Its cost has been 271, 625*l.* The Crévecœur bridge, crossing the Maas, has ten openings, each of 187 feet, and one main span of 328 feet. This work which has been undertaken for the sum of 93,000*l.*, will not be finished until the close of the present year. In the north of Holland, also, the railway between Zwolle and Leuwarden has been completed by the bridge across the Yssel, in ten spans, one of which is 321 feet 6 inches in the clear, the rest of the viaduct being made up with smaller openings, among which is a swing span of 51 feet 6 inches in length.

Towards the close of the year a suspension bridge across the Moldau, at Prague, was opened for traffic. It is intended for foot passengers only, and is 629 feet in length, the space being divided with a central pier. The width of platform is very inconsiderable, being only 11 feet. It is worth noting that the links forming the suspension chains are of Bessemer steel; the contract price was 18,500*l.*

In February last a stone bridge at Fucecchio, over the Arno, was completed. It consists of five arches of about 74 feet each, and cost some 8500*l.*

The arched bridge of Bessemer steel which, it will be recollected, carried the Quai d'Orsay over the road between the Exhibition and the bank of the Seine, has been removed, and re-erected on its permanent site over the Vilaine, at Port-de-Roches. In its temporary position the arched girders, eleven in number, had one clear span of 82 feet, so as to obtain the necessary width. In its present position, however, it has been lengthened out into three spans, each composed of four ribs, giving a width between the parapets of 19 feet 8 inches. The total cost of the steel work of this bridge was but 2612*l.*

We have to turn, however, to America to find the great examples of bridge construction during the past year. The extension of railways westward, across the great rivers of the continent, have involved much work; but two of the principle bridges are in progress to effect a metropolitan communication. Of these the first is that intended to connect New York City with Brooklyn, and will span the East river with a clear stretch of 1600 feet. This was Mr. John A. Roebling's last and greatest work, at the first stage of which he lost his life. The bridge is, however, being carried out by his son, and when completed will be the largest in the world. During the last year the caissons for the foundations have been partially built, and considerable excavation on the site of the piers is being carried on. When completed the towers will have a total height of 300 feet, and will carry the wire cables, from which will be suspended a double roadway for passenger and steam railway traffic.

Second in importance is the arched road bridge over the Mississippi, at St. Louis, with its central span of 515 feet, and two side arches of 497 feet each. This enormous structure, designed for railway as well as passenger traffic, is well in progress, under the superintendence of its engineer, Mr. James B. Eads. It will be remembered that we have described this work at great length in the sixth volume of ENGINEERING, and that on page 345 we published a large engraving showing its general design, as well as the details of its construction. Its total cost will be about 640,000*l.**

The Quincy bridge, although actually opened for traffic in 1868, may be included amongst the last year's bridge-work of the States. This is the longest bridge spanning the Mississippi, the river at the point of crossing being 3,250 feet in width, the navigation channel, however, being only 800 or 900 feet broad. The bridge is divided into seventeen spans, two of 250 feet, three of 200 feet, eleven of 137 feet, and one large draw span 360 feet long, the girder of the latter being 36 feet in depth. The piers of the fixed spans are all of masonry, that of the swing is formed of four wrought-iron cylinders 14 feet in diameter, sunk through 50 feet from the water level; upon the top of these a turntable, 30 feet diameter, rests, and carries the span. The total cost of the work, designed and carried out by Mr. Thomas C. Clarke for the Quincy Railroad Bridge Company, was 215,000*l.*

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* Accounts of this and other American bridges will be found in the various volumes of the *Journal of the Franklin Institute* for the last five years.—ED.

At Omaha, in the State of Iowa, four railway companies—the Union Pacific, the Chicago and North-Western, the Chicago and Burlington, and the Chicago and Rock Island—combined last year in the construction of a long bridge across the Missouri, designed by General G. M. Dodge, the engineer of the Union Pacific Railroad. This bridge is 2800 feet in length, divided into eleven spans of 250 feet each, resting upon concrete filled, cast-iron cylinders 8 feet 8 inches in diameter. Some of them require to be sunk to a depth of 70 feet below low water, making the total length of column 139 feet. The superstructure of this bridge is formed of ordinary wrought-trussed girders, with cast-iron top member. In addition to the bridge itself, approaches three miles in length are also required, principally formed of trestle work.

Action has also been taken in the matter of the Cornwall Bridge, to cross the Hudson river, about 40 miles above New York City. The total length of this work, with approaches, will be 2500 feet, the clear span 1600 feet, the same as that of the East river bridge, and the height of towers 280 feet. The platforms, railroad and passenger, would be carried by wire cables (70,300 miles of wire would be required,) upon Mr. Roebling's system, and the estimate of the whole work is 500,000*l.* The main object attained by this bridge would be the transfer of the vast coal traffic of the Hudson river to the railway companies between Pennsylvania and the New England States.

Last January, a new bridge across the Niagara river, about half a mile below the Falls, was opened for general traffic. This work was erected by Mr. Samuel Keefer, for the Clifton Suspension Bridge Company, under two Charters, one from the State of New York and one from Canada. The total authorized capital was $400,000.

This magnificent bridge spans the gorge of the Niagara river, where its depth is 180 feet, and its rocky sides rise up some 80 feet to the level of the table land above. The span between the points of suspension is 1268 feet 4 inches, and the deflection of the cables in the centre is 90 feet. The towers are 100 feet in heighth, built of white pine, and disposed in pairs, each of the form of a truncated cone, 28 feet square at the base, and 4 feet square at the top. The towers are placed 13 feet apart (in the clear) at the base, and they are braced together at intervals for their whole height. Two cables carry the platform over the towers, where they are 42 feet apart, converging to 12 feet apart at the centre of the bridge. Each cable is composed of seven ropes, twisted from seven strands, and every strand contains nineteen wires ·155 inch in diameter. All the wires in the cables were drawn in one length, so that the cables are without splice or weld from end to end.

The platform is supported by a combination of diagonal and vertical rods; of the former there are 48 in all, reaching from the towers half way to the centre of the bridge. They are formed of wire rope varying in diameter from 4½ to 3 inches, according to their position. The vertical suspenders are also of wire rope ⅝ of an inch diameter, and placed at intervals of 5 feet. There are altogether 480 of these, representing an aggregate strength of 4,800 tons. In addition to these supports 54 guys are introduced to steady the platform, of these 28 are on the up-stream and 26 on the down-stream side. These extend nearly to the centre of the bridge and are moored into the rocks on each side. The roadway is stiffened by a light wood and iron longitudinal truss, 6 feet 6 inches deep, and going down 2 feet 6 inches below the platform level. Transverse floor beams of pine, bolted together in pairs, and placed in groups at intervals of 5 feet, rest upon the longitudinal girders, and upon these is placed the flooring, formed of two thicknesses of pine 1½ inch thick.

In Philadelphia a new bridge across the Schuylkill has been set in hand, with two platforms, the one to remove the railway from the level of the streets through which it ran, to the infinite inconvenience of the street traffic, and the other to effect an improved communication between the large streets of the city. When completed, this bridge will have a clear span of 340 feet and a depth of truss of 35 feet. The work is being carried out by Mr. J. H. Linville, of Philadelphia.

On the New Haven, Middletown, and Willimantic Railroad, between New York and Boston, a bridge to span the Connecticut has been decided on. Its total length is 1248 feet, and two of the spans will be formed to swing, with openings of 160 feet each. The clear headway above the water is 42 feet and the depth of the truss is 20 feet.

At the beginning of last year an important bridge over the Mississippi, at Dubuque, Iowa, was opened for the accommodation of the Union Pacific Railroad. Its total length is 1760 feet, divided into seven spans, the principal of which is a swing 360 feet long, and turning on a centre pier 20 feet in width. This bridge was constructed by the Keystone Bridge Company, of Pittsburg, in less than eight months.

Lastly, among American bridges of the past year, we may mention the great work across the Missouri river at Kansas City, designed and erected by Mr. O. Chanute, and representing one of the most successful examples of bridge construction in America. The total length of the bridge is 1387 feet, divided into seven spans, one of which is a draw span 363 feet in length. Besides the bridge itself, the approaches involved the construction of 2360 feet of trestle work viaduct. We have so recently described this work, that we need hardly refer to it again in any detail; it will be remembered that the great difficulties lay in the foundations, and that the rapid current, the impetuous floods, and the ever shifting bottom, brought about some failures, and necessitated an almost unprecedented amount of skill and care on the part of the able engineer to whom this work was entrusted.

At home, with two notable exceptions, we have but little to show for the past year's work in bridge construction.

At Halifax, a cast-iron arched bridge, in two spans, by Mr. John Fraser, of Leeds, has been completed; the openings are each 160 feet, with a rise of 16 feet. The architectural effect of this bridge is good, the spandril filling and parapet well designed. It will be remembered that we illustrated and described this work in May last. (See *Engineering*, vol. vii., p. 299).

The two great metropolitan bridges have been finished this year —the Holborn Viaduct and Blackfriars-bridge; of these detailed accounts and engravings will be found in *Engineering*, of the former in vol. vii., page 407, and of the latter in vol. viii., page 310.

At the Woolwich Arsenal, the pier designed by Mr. J. W. Grover, for the shipping and unshipping of guns, is in progress. This pier has a total length of 328 feet, divided into six spans of 48 feet each. The width of the platform is 22 feet 6 inches, and the size of the pier head is 40 feet by 50 feet. A 30 ton crane, resting upon a 7 feet diameter cylinder, is placed at the end of the pier. The cost of this work will be 10,000*l.*

The proposition for the widening of London-bridge has been seriously discussed during the past year, and many schemes have been submitted to the consideration of the Common Council. Of these we need only say that not one, which proposes to add considerably to the width of the platform, whether by cantilevers, or girders placed alongside the existing structure, at all fulfils the requirements of the case. It is not likely that any action would be ever taken to carry out alterations which would mar the bridge entirely; but it is an additional security that the foundations of London-bridge have all their work to do in carrying the structure as it at present stands, and that any additional load could not be safely applied. Meanwhile attention is turned towards the practicability of making Southwark-bridge convenient for ordinary passenger transit, and by so doing to divert part of the London-bridge traffic.

A new bridge across the Thames at Wandsworth has recently been proposed, and will doubtless be decided upon. The design, however, has not yet been prepared.

Finally, we may refer to the Pons Asinorum, or Boutet's bridge, designed to cross the channel between Dover and Calais in any number of spans desired, and comprising besides, the advantages of houses of refuge at the piers for shipwrecked mariners and such like. This bridge, we need hardly remind our readers, is designed upon the novel and scientific principle, that if you stretch a single cable as far as it will possibly go without rupture, and then a little further, it will break; but if you put half a dozen such cables together, you obtain an infinitely strong foundation whereon to construct. But Boutet has not yet revealed the secret whereby he stretches cables, not only until they cease to sag, but have a considerable camber.

Oxide of Manganese has been used in England for lining puddling furnaces. During the finishing of the metal, the manganese, is said to separate in the form of silicate, carrying with it other impurities, such as phosphorus and sulphur.

RAILROAD BRIDGES.

Iron Truss Bridges for Railroads. By Brevet Col. W. E. Merrill. Published by D. Van Nostrand, N. Y.

In these days, it is certainly not from the lack of published material, that the action of strains in engineering constructions is not thoroughly understood by all members of the profession, and this is especially true of Trussed Girder Bridges. Ten years since there was very little literature on the subject, and there were but few engineers at that time well versed in this interesting branch of the profession. It is true Mr. Whipple's original essays were published about 1847, but the edition was small, and being published by himself, they had not the notoriety or authority they would have had if brought before the profession in a more public manner. However, a sufficient number found their way into competent hands, and have been productive of some of the best engineering practice of the present day.

The practical application of the principle of the lever to the discussion of strains, the economy of using braces at 45 degrees, are some of the points beautifully developed by Mr. Whipple. Four or five years after, Bow in England, and Haupt in this country, published works on the subject. The former treating the subject much like Mr. Whipple, and covered in an unusually clear manner the action of strains in almost every form of bracing. Mr. Haupt's book, excellent in many respects, was not as concise or easy of application as either of the above, and was particularly muddy in the consideration of the action of variable loads.

He adopted the principle of moments for estimating the horizontal strains, and as wooden bridges were more particularly considered, only the centre section entered the calculations. The principal value of the work lay in the analysis and descriptions of various bridges on the Pennsylvania Railroad, mostly built by the author. There was little or nothing bearing upon iron bridges. Prof. Rankine's work on Civil Engineering soon after appearing, still further discussed in his keen analytical manner, the strains on bridge girders in methods which for the most part are simple in their application. These works, in connection with Edwin Clark's great treatise on the Menai and Conway tubes, covered the ground so completely that a careful student need but to master them, to make himself thoroughly acquainted with the subject. We have really nothing new in substance at this present time, although several valuable pamphlets and treatises have been published from time to time, mostly differing from each other in plan and arrangement. The "Theory of Strains," in 2 Vols., by Stoney, are all that could be desired, and form a most complete treatise on the subject he discusses. It is a standard work in every respect. Mr. Unwin's "Iron Bridges and Roofs" is another excellent work, particularly valuable in his remarks upon the designing of details of construction. And in our summing up of standard books on this branch of engineering literature, we must not forget Mr. Humber's last contribution, the "Handy Book of Strains," a book that should find a place on every office table, wherein he develops the rapid method of computing strains by graphical construction, supplemented by simple but accurate formulæ. Then, again, we have among pamphlets, Mr. Shaler Smith's "Comparative Analysis of the Fink, Bollman, Murphy and Triangular Trusses," published in 1865, which has met with deserved favor, for the common sense with which he has treated his subject, basing his analysis upon that of Mr. Whipple, which has not been excelled for rapidity of application or accuracy of results. We do not profess to have mentioned all the published material on this subject, but were induced to thus preface what we have to say in reference to Col. Merrill's book, from his opening remark, that he "labored under great difficulties from inability to procure clear and simple instructions how to calculate strains in trusses," &c., and again, on page 11, "Though much discussion has been given to *arches* of all kinds, but few engineers have taken the trouble to work out thoroughly and carefully the problem of *truss bridges*." We venture to say that more engineers will undertake to correctly proportion and carry out a truss bridge, than an arch of a span beyond an ordinary culvert. We suppose our author refers to West Point Engineers, with whom the problem of the arch is all important, and to Captain Woodbury's paper on the subject, published by the department. We have, indeed, plenty of theory on the arch, in which so many uncertain elements are forced on us from the nature of the problem, that after all the construction of them is largely empirical.

However, be that as it may, our author has done injustice to a long list of able authors, as the above remarks indicate. His book bears witness to great industry, and abounds in mathematical discussions, showing a fondness for that subject. In his chapter on the action of strains, we find the old story of the composition and resolution of forces, much better told, by the way, in almost any of the authorities quoted in the first part of this article. On page 23 we find a new element introduced into the calculations, which he calls "extra strains," and which is brought down to a very fine point. The idea is based on the assumption, that inasmuch as cast iron top chords are for obvious reasons cast in panel lengths, it is mechanically impossible for the ends to be so faced as to give adjoining sections perfect contact, "causing sagging in some places, and a tendency to rise in others," which is peculiarly the case in the "Fink and Bollman Bridges," especially the latter, where it is necessary to have panel posts and ties at intervals *merely* to support the top chords. He then proceeds to make the exact figures for this extra strain. In order to do this it is assumed that in all bridges to be afterwards examined "that the top chords are equal, a difference in strain being met by a difference in thickness, and that the panel lengths are the same in all." The uniform radius of top chord is taken at 9 inches for a 200 feet span, (just fancy for that span a chord 18 inches in diameter!) the panel length being 12 feet 9 inches. The hypotenuse of the triangle (sides 9 inches and 150 inches) is then computed, which "represents the compression on the segment of the top. The downward tendency in this case would evidently be $\frac{9}{150 \cdot 3}$ or $\frac{1}{17}$ the compression on the segment." In these days of workshop tools, if all bearing surfaces did not come together true after facing, it would be owing to gross carelessness. This extra strain is entirely suppositious on the author's part, and practically cannot exist, in any of the work turned out of our best engineering firms, as an inspection of their mode of construction will show. The introduction of its consideration in the analysis of strains, is unwarranted by the facts, and we take it to be a purely imaginary quantity, which we can safely eliminate, without any fear of our work falling down.

On page 25 the author commences a most elaborate discussion of Hodgkinson's experiments on cast iron pillars, and his formulæ are put through a course of mathematical jugglery, bewildering to follow. It is stated that we must obviously use the round end formula for bridge struts, probably having in his mind the details of construction used by Mr. Post in his bridges, where the struts as well as ties terminate in eyes at either end, and thus have a pin connection. It is usual and practically correct to regard the struts as having one end rounded and one end flat, in computing their strength, in all bridges, so far as we know, the above exception being the only one at present before our mind. We believe the formula as given by Messrs. Hodgkinson and Gordon, are simpler than those recommended by Col. Merrill, and will be continued in use, until we have something more reliable. They are both empirical, and as the latter gives smaller results, thus erring on the side of safety, it is preferred by engineers, *not* because they cannot use logarithms as the author seems to infer. The most incomplete information we have on the whole subject of strength of materials, is on the resistance of iron in the form of struts or columns to compression. In Van Nostrand's magazine for January there is a reprint of a paper read before the Institute of Civil Engineers (London), upon the shortcomings, so to speak, of our knowledge on this subject, which well embodies the difficulties we at present labor under.

We need sadly a series of experiments upon the subject, and it is to be hoped that before long some one of our professional societies will take the matter in charge, and settle the vital questions involved. Assuming the formulæ of the author to have been deduced correctly, we are at a loss to see wherein their utility lies, over those in ordinary use, as there is no commensurate gain for the trouble of applying them. The engineer actively employed in his profession is forced to take the most direct means of arriving at a result, consistent with accuracy, and cannot select that formula as best, simply on account of its beauty in a mathematical point of view, which view is always gauged by the difficulty of comprehension to ordinary mortals. We do not say this especially with reference to the book before us, although it has called forth the remark, but because the tendency of many writers is to invest with a halo of mystery a subject that might be readily understood if put in plain English.

There are very few engineers with ordinary mathematical acquirements but who could apply either Hodgkinson's or Gordon's formulæ, and who, if dependent on the methods recommended by our author, would find themselves rather involved. Mosely's Mechanics is an elegant exposition of the subject, but who ever heard of any of his formulæ being applied in the shape he leaves them, unless perhaps the formula for the deflection of beams. In fact, we doubt if one engineer in fifty could understand him, letting alone the application of any of his formulæ to design. Gen. Morin's

Mechanics, on the other hand, is a common sense treatment of the subject, written with a view to use, and to that practical end, his reasoning in the main can be followed by the merest tyro in mechanics, and require no "advanced" mathematics. Even the formulæ for weights, in the case of struts, involve the use of logarithms, and although logarithms are valuable in their place, they involve the use of tables and take more time than would be required in figuring the usual way. Engineering constructions do not require the accuracy of astronomical calculations, and were it not for the occasional occurrence of a mixed power, as in Hodgkinson's formulæ, it would not make much difference if the engineer never saw a logarithmic table, after leaving college.

Leaving now our author's formulæ upon "columns" to those who enjoy and appreciate ingenious transformation and mathematical skill, we come to a comparison of various trusses. The trusses considered, are the "Fink, Bollman, Jones or Howe, Murphy, Whipple, or reversed Howe, Post, Triangular, Linville or Pratt." To this nomenclature we object. In the first place we cannot understand why a Howe Bridge, made in iron, should be called a "Jones" truss. Such bridges were in use years back on the Pennsylvania Railroad near Philadelphia, and have answered a good purpose. Calling the Murphy Whipple a reversed Howe, was an idea probably taken from Mr. Smith's able pamphlet, before referred to, whose system of diagrams, by the way, our author has judiciously adopted. We have before us a bridge built by Mr. Murphy on the Lehigh Valley Railroad near Allentown, somewhere about 1860, (we think before,) showing the principle first recommended by Mr. Whipple, viz., vertical posts, and diagonals at 45°. There are two sets of triangles and it differs from Whipple's Bridges, simply in arrangement of details of construction. The same is true of the Linville Bridge (which is *not* a Pratt) being nothing more than our old friend the Whipple, with modernized constructive details, and a wise recognition of the value of wrought iron for compressive members.

The Pratt Bridge is truly a reversed Howe, that is, verticals acting by thrust, and diagonals by tension. Throwing aside the consideration of material and details of construction, and classifying the trusses analyzed from their diagrams or principles of action, so to speak, we have the following:

Howe, Whipple, Pratt, (or reversed Howe,) Bollman, Fink, Post, Triangular. These are in order as the various systems were introduced into this country. If this classification is departed from, it might be as well to call any bridge built after its builder, and if persisted in, we will have the Smith Bridge, the Brown Bridge, (Jones we have,) and so on to the end of the chapter.

In making comparisons of bridges as to economy, it is customary to estimate the line diagrams, and then throw in a certain percentage for joints and the like. This will often mislead judgment to incorrect results, for the detals of construction may be more expensive in one mode of design than another, which would not show in comparisons as usually made. As a rule in iron work, when rectangular connections are departed from in compressive members, extra expense is involved, as in the Warren, or Triangular girder, which although theoretically more economical than a Whipple, proportioned to like duty, will cost more to practically carry out. Any one at all acquainted with shop practice can readily understand this; and as the tendency of the times is to discard cast iron for this class of work, and substitute wrought, this remark has particular force. It may be worth a cent a pound more to build a certain style of bridge over another style, and yet both bridges may be as near as may be the same weight.

In comparing his trusses, the author has selected but one circumstance to draw his conclusions from, and that is that of the *through bridge*, the most disadvantageous for the Fink or Bollman, and the most advantageous for the Post Bridge and the like. The result could be seen beforehand without the figures. As a deck bridge there is none cheaper than the Fink as far as material goes, and its curve of deflection is necessarily the most uniform of any. In arranging the weights for a bridge to carry, Col. Merrill, in common with Mr. Smith, breaks up the weight into that of the engine, tender and cars, which perhaps for spans, say 150 feet, may make an important difference, but we very much question in spans over 150 feet, whether the extra labor involved in making the computations, is compensated by any saving, over an assumed rolling load, of so much per foot, and an extreme panel load of so many tons per panel, produced by the engine.

In the computations we first discover the author's mode of treating the "counter," and at variance with the best practice and authority. He assumes it to have the same positive action as the main braces, and transmitting the proportion of moving load, over the long arm of the lever. This requires it, then, no matter what the span, to be run out to the end panels, and to have a sectional area sufficient to carry the above proportion of the load to the further abutment. We are aware that Mr. Post does this, and more, for after one of his bridges is erected, he loads them with the maximum load, and while thus strained, he screws down all his counter-braces (then relaxed). A permanent strain is thus kept in the main braces, any passing load thereafter, simply relieving his counters. This accounts for the small deflection his bridges usually have, after being handed over for service. The idea is an old one, and originated, we believe, with Col. Long, who, in his wooden bridges, used wedges to attain the same end.

In this way the deflection, of course, is kept in the bridge, and when subjected to future loads, there can be little more, which (if it exists at all) is due to the elasticity of the material or imperfect joints. We know of no other iron bridge where this mode of applying the counter-braces is in practice.

The question of the counter-brace has been much discussed, and its office well established, in view of which we were somewhat surprised at finding in the treatise before us, that the author has computed them precisely as if they directly carried weights to the farther abutment. Provided the bridge itself was devoid of weight, he would be correct; but as it has, the counters are relieved at each panel by so much of the permanent load as occurs at that panel. In long span bridges, where the dead load is large in proportion to variable load, the counters are of real use only for a few panels on either side of the centre of truss, while in small span bridges they may be required at every panel from end to end. Usually they are carried one or two panels farther than theory requires for stiffness, and only in those cases where their use is indefinitely understood, are they carried from end to end of bridge, no matter what the span.

The remarks upon the value of cast iron as compared with wrought iron for compressive members, will find but small support from most engineers. The convenience in procuring castings leads many engineers to adopt it, although preferring wrought iron, which requires greater skill in its construction, as well as facilities possessed only by the largest shops.

For railway purposes (except a few instances) wrought iron posts are now insisted upon, and tenders for any other will not be considered. And the conviction is so strong in the superiority of wrought iron for compressive members in truss bridges, that the above restriction is frequently made to cover even the top chord. This arises from no unfounded prejudice, as a proper study of the physical peculiarities of the two metals will develop.

The stiffness of a bridge is usually measured by the amount of deflection, when loaded with its maximum load, and the more nearly the truss recovers itself after this load has been removed, the more perfect is the mechanical connections of the parts and the elasticity of the material. Disregarding any imperfection of workmanship, the deflection is due to the shortening of the top chord, and a lengthening of the bottom under the strains of compression and tension caused by the loading. Were the material perfectly elastic, on the removal of the load, the bridge would resume its original level.

As such cannot be the case a certain permanent deflection or "set" is left in, which is greater or less according to the material employed.

Mr. Edward Clark's experiments show that wrought iron has a remarkably uniform rate of elongating and shortening, as near as may be $\frac{1}{10,000}$ of its length for every ton per square inch put upon it, up to the point of permanent injury, or about twelve tons per square inch, and it will recover its normal length, on removal of the pressure, nearly, if not quite up to this limit.

Cast iron, on the other hand, changes its length nearly *twice* as much for every ton of imposed load, and this change is very irregular, especially after a load of about four tons to the inch is passed. It does not recover itself fully after the load is removed, even when that load is but one ton to the inch. These properties are sufficient to give wrought iron the preference for compressive members in bridge construction, without taking into consideration the fear of imperfect castings, or in the case of long posts, the extra weight required to insure any kind of a sound casting, and to make up for possible floating of the core, cinders, bubbles and other concealed flaws. This forced excess of work makes a wrought iron post to come cheaper than a cast iron one, and also gives the bridge less weight to carry, besides resisting a tendency to flexure as no cast iron column could do.

On the question of deflection, this peculiar relation of the setting properties of cast and wrought iron may be inferred. The former kind of chord being permanently shortened with any imposed load, while the latter possesses the capacity of recovering its length when load is removed.

The consequence is, that if two bridges, one having a top chord of cast iron, the other of wrought, and assuming workmanship the best of its kind in each, the latter would deflect the least. Although we never have had the opportunity to test this upon actual bridges, we believe, our conclusion, based as it is on known physical facts, would be fully borne out should such an experiment be made.

We have not by any means exhausted the points of superiority of wrought iron over cast, in the condition of compressive members in bridge trusses, but trust that sufficient has been said to lead one to a correct judgment.

Returning now to our author, he sums up his investigations of trusses, in the order of their "economy," in pounds of metal, computed simply from their line diagrams, with 15 per cent. allowed for piers, nuts, joints, &c., the same allowance as made by Mr. Shaler Smith. As an interesting comparison we place in juxtaposition the trusses in the order of economy for *through* bridges, according to Whipple, Smith and Merrill.

	SMITH.	WHIPPLE.	COL. MERRILL.
1	Triangular.	Whipple.	Post.
2	Pratt (called Murphy)	Post.	Triangular.
3	Fink.	Bollman.	Whipple.
4	Bollman.	Fink.	Pratt (called Murphy).
5	....	....	Fink.
6	....	....	Bollman.

We cannot forbear, in this connection, quoting a table from Mr. T. C. Clarke's valuable work on Quincy Bridge (published in the beginning of 1869). The table is made up from the bill of material required to construct a 200-foot span, on the Post, Triangular and Whipple systems. It possesses the further value of having been taken off the drawings handed in by the interested parties for the above great bridge.

NAME.	CHORD SYSTEM.			BRACING SYSTEM.				LATERAL SYSTEM.			Weight of Iron.	Weight of Track.	Total.	REMARKS.
	Upper.	Lower.	Total.	End posts.	Interior posts.	Main and Counter Braces.	Total.	Upper and Lower Bracing.	Floor Beams.	Total.				
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Weights do not include end pedestals, rollers or bed plates. Weights given are per foot run.
Post...........	535	276	811	53	191	165	414	50	85	135	1,300	275	1,635	
Triangular...	250	195	445	75	200	105	330	75	160	235	1,060	275	1,335	
Whipple......	244	190	430	61	196	141	398	65	170	235	1,067	275	1,342	

It will be noticed from this that the two last use less material than the first in the list, except in the item of floor beams. This is owing to the fact that the design of the Post Bridge, contemplated the use of 9-inch rolled beams, while that the others showed 15-inch beams, the difference in weight of such beams being about 20 pounds in every foot.

With all this advantage, the totals speak for themselves. After all, this question of economy in bridges is one of dollars and cents, and if properly proportioned of good material and carefully constructed they all answer a good end. Our preference is for the Whipple, simply because it is more easily and cheaply constructed than perhaps any of the others, for a through bridge, besides which it requires as little material practically as any of them. As designed by Mr. Linville it is a handsome bridge, and he deserves the thanks of the profession for making an effort to combine good architectural effect with wrought iron construction. The Post bridges are excellent ones, but are not handsome, and we cannot agree either in the cast iron parts, nor the form of strut adopted. However, they stand well and give satisfaction, so far as we know, to those using them, a good test of their efficiency. Even he is adopting wrought iron in his more recent constructions, whether from conviction or because railway companies require it, we do not pretend to say. We cannot say that our review of Col. Merrill's book is a brief one, but we admit it to be incomplete, as necessarily it must be from the nature of the subject.

There are other points that we should like to touch upon, but cannot do so without extending this article beyond an appropriate limit. Although conscious of many imperfections in our treatment of the subject, we believe that we have been fair and just, and had the treatise under review appeared ten years since, we would have been less critical. As it is, nothing of any practical importance has been added to our stock of engineering literature, which we are sorry to say of any book. In these days of book-making it is pretty difficult for one to discriminate as to the best book on a given subject, so many have good titles, but only lead the beginner astray, either through incorrect deductions, or through a mode of treatment that makes an easy subject difficult. A. P. B.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

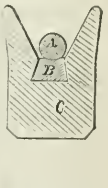
(Continued from page 29.)

Telodynamic Transmission.

For the following we are indebted to the interesting "Report on Machinery and Processes of the Industrial Arts," by F. A. P. Barnard, LL.D., U. S. Commissioner to Paris Universal Exposition, 1867.

We give only those parts which add new facts to the statements already made in an article on this subject.

"The wheels are made as light as is consistent with strength, not only for the sake of reducing the inertia of the moving mass, and the friction on the axes to a minimum, but for the more important object of diminishing the resistance of the air. It can hardly be doubted that an abandonment of spokes entirely, and making the pulley a plain disc, would improve essentially the performance could discs be made at once strong enough to fulfill the required function and light enough not materially to increase the friction. It will be seen further on that the resistance of the air, which Mr. Hirn admits to be equal to the sum of the other resistances, is, in fact, more than double all the rest put together.



"This figure, which is a half size cross section of the rim C of the wheel, represents the form of the groove into which the armature B of gutta-percha is compacted, and upon which the wire rope A rests. The dove-tail enlargement of this groove at the base is necessary, not merely to secure the gutta-percha against displacement by ordinary causes, but to prevent its being detached by centrifugal force. Mr. Hirn assumes 30 metres per second to be the velocity which it is expedient ordinarily to give to the circumference of the wheel; but he has carried this occasionally as high as 40 metres.

At 30 metres the centrifugal force generated at the circumference of the smaller pulleys of 2 metres in diameter, will be between 90 and 100 times the force of gravity, and at 40 it will be nearly 170 times gravity. That is to say, as the circumference of such a wheel measures a little over 20 feet around, if each foot of this circumference weighs one pound, the whole will be dragged in all directions with this last velocity by forces which unitedly will amount to nearly $1\frac{3}{4}$ tons. It is on this account that Mr. Hirn suggests that the limit of 30 metres, had better not be overpassed, higher velocities endangering the destruction of the wheel.

"The invention of Mr. Hirn was first applied in the transmission of moderate powers to moderate distances."

"Instead of a cable there was used in the beginning a band of steel, having a breadth of about $2\frac{1}{2}$ inches, and a thickness of $\frac{1}{25}$th of an inch. This presented two inconveniences. In the first place on account of its considerable surface, it was liable to be agitated by the winds; and, secondly, it soon became worn and injured at the points where it was riveted.

"It served, however, very well for eighteen months to transmit 12 horse-power to a distance of 80 metres.

"A cable was then substituted, and this first introduced in 1852, is still in good condition.

"The applications have been made for the most part in France, and in the department in which the invention originated, but there are some notable exceptions."

"In the great government manufactory of gunpowder at Okhta in Russia, which was destroyed in 1864 by explosion, it was determined in the reconstruction of the works to erect the buildings at such a distance from each other that the explosion of one of them should not involve, as happens usually in such cases, the ruin of all the rest.

"This new manufactory which went into operation in 1867 is composed of thirty-four different workshops or laboratories, to which motive power is transmitted from three turbines, having a total force of 274 horse-power along a line nearly a mile in length.

Several establishments in Germany employ it for distances varying from 350 to 1,200 metres. An officer of the Danish Navy has made one application of it on a line of 1,000 metres, and at the mines of Falun, in Sweden, more than 100 horse-power is transmitted by it to a distance of 5,000 metres.

"The cost of the machinery and its erection is estimated at 5,000 francs per kilometre, exclusive of the necessary constructions at the termini, which will require an additional expenditure of 25 francs per horse-power. In the case of 100 horse-power carried 10 kilometres, the total expense will therefore amount to 52,500 francs.

"For its practical value, this invention, simple as it appears, is one of the most important that has presented itself in the Exposition, and the jury have shown that they so regard it, by awarding to the inventor the distinction of a grand prize."

(To be continued.)

Suez Canal.—The latest information published by the *Official Journal* of the canal gives the following among other information. It quotes two telegrams, in the first instance, one dated Ismailia, December 27, the other Port Said, December 30. The first runs thus:—"The steamer Stirling, from Glasgow, of 800 tons, arrived at Port Said, and proceeded direct for Bombay, the voyage through the canal having been performed in less than sixteen hours. Upwards of 50 steamers are lading in different ports of Europe which will pass through the canal." The second telegram states that the engineers report that the state of the canal banks presents no perceptible change since the inauguration. The French steamer Malta, and the English steamer Rocket, on her way to Shanghai, have passed the canal. At Serapeum, where the canal was too shallow, it has been deepened to 19½ feet, and there remained only 2 metres to complete the whole length of the canal, out of about 80 metres. To gratify the impatience of the shareholders the names of some of the largest of the vessels that have passed, or will pass, are published, and are as follows:—At the head of these are English vessels: the Brazilian, of 2,815 tons register; the Queen of the South, 2,097 tons; the Mauritius, 2,150 tons; the Port Said, 898 tons; the Ismailia, 899 tons; and the Bolivian, 2,815 tons. The vessels belonging to the Ocean Steamship Company are to pass regularly through the canal.

Mechanics, Physics, and Chemistry.

ELECTRICAL MEASUREMENTS.

On the Atlantic Telegraph Cables of 1865 and 1866. By the Coast Survey expedition of 1866, under Dr. B. A. Gould.

[In the report of the above expedition by Dr. Gould, which has just been published in the Smithsonian Contributions to Knowledge, we find various matters of interest on this subject, from which we have made the following extracts.—Ed.]

From the beginning it was part of my design to arrange and make a system of experiments for obtaining general answers, so far as might be possible, to sundry interesting questions to which previous investigations had afforded no satisfactory replies. Among these were—

1. The character of the agency which gives the telegraphic signal upon the closing or interruption of the galvanic circuit, and the route by which its transmission is effected.
2. The influence exerted upon the conductor by using the earth as part of the circuit, or by placing the complete circuit in electrical communication with the earth.
3. The extent to which the velocity of propagation of the signals is dependent upon the intensity of the electromotive force and upon the resistance of the conductor.
4. The equality or difference in speed of the signals from the positive and from the negative electrode, when the other is connected with the earth; as also the relative velocity of signals given by completing and by interrupting the circuit.

Of course it was not to be expected that satisfactory information could be obtained, or crucial experiments devised regarding all these points; but these were the guiding ideas in providing for the additional experiments, which were carried out with the friendly aid of the gentlemen of the telegraphic staff on the 1st, 10th, and 16th of November.

The length of the cable of 1865 is 1896·5 nautical or 2186 statute miles, and that of the cable of 1866 is 1851·6 nautical or 2134 statute miles. Expressed in metric units, the cable of 1865 is 3518 kilometers, and that of 1866 is 3435 kilometers long.

In each cable the conductor is formed by six copper wires twisted around a seventh one. It has a diameter of 0·147 inch or 3·7 millimeters; and weighs 300 pounds to the nautical mile, 73·476 grams to the meter. The copper was guaranteed by the manufacturers to have a chemical purity of 85 per cent., and its specific conducting power (that of pure copper being 100) was found by test to be

93·1 for the cable of 1865, and 94·6 for that of 1866. Its specific gravity as determined by Mr. Willoughby Smith was 8·90.

The electrical tests of the cables, after they were laid and in complete working order, had been made by Mr. Latimer Clark, a short time previous. They gave the following values, expressed in terms of the standard units,* adopted by the British Association for the Advancement of Science, and which promise to become generally accepted, as a peculiarly convenient system of electrical measurement.

The cable of 1865 gave† a resistance of 4·01 ohms to the knot; the "insulation" or resistance of the coating, being 2945 megohms to the knot; and the electrostatic capacity 0·3535 farad to the knot, or about one farad to each 3¼ statute miles.

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* This excellent system of measures is derived from the absolute electrodynamic units of Weber, by multiplying them by such powers of 10 as shall refer them to a convenient scale.

The unit of force f is that force which, acting during 1 mean second upon a mass weighing 1 gram. would impress upon it a velocity of 1 meter in 1 second. It differs from the meter-gram, which is the force requisite for lifting a gram through a meter in a second, and is 9·80868 f.

The unit of current c is that current which acting through 1 meter, at 1 meter distance exerts the force f upon a similar current. It decomposes about 92 milligrams of water in each cell in a second, consuming about one-third of a gram of zinc.

The unit of resistance r is the resistance of the conductor which transmits the current c in 1 second.

The unit of electromotive force e is the tension which maintains the current c with the resistance r.

The unit of quantity q is that amount of electricity which flows in the current c during 1 second.

These measures, 'absolute' in so far as they depend only upon the gram, the meter, and the second, are referred to convenient scales in the British Association's system; the measures adopted being named in honor of eminent discoverers in electrical science, in accordance with a suggestion of Mr. Clark.

The measure of electromotive force is $10^5 f$, or one hundred thousand times the absolute unit.

This has about 0·927 the tension of a Daniell's cell, and is called a *volt.*

The measure of resistance is $10^7 r$, or ten million times the absolute unit.

This is about 1·0456 times the unit adopted by Siemens, and is called an *ohm.*

The measure of quantity is $10^{-8} q$, or the hundred millionth part of the absolute unit.

This is called a *farad*

Consequently, with a tension of one volt, and a resistance of one million ohms, the quantity of electricity would be one farad in each second.

Moreover since the volt-farad is $10^{-3} f. q$, we have 1000 volt-farads = the absolute unit of work; or 9808·08 volt-farads per second = the meter-gram.

One million of ohms is conveniently designated as a *megohm*; and one million of farads as a *megafarad.*

† In the manufactory, the resistances found in each knot, at the temperature 75° Fahr. were 4·27 and 4·20 ohms, for the two cables respectively; and the respective insulating capacity of the coverings, 349 and 342 millions of ohms to the knot. These data show an increase of conducting power by 6 per cent. for the cable of 1855, and 8 per cent. for that of 1866; while the insulation had been increased in the ratios of 8·44 and 7·13. Hence, we may roughly infer the average temperature of the cables to be not far from 5° Centigrade in their ocean bed.

The cable of 1866 showed for each knot a resistance of 3·89 ohms, and an insulation of 2437 megohms; the electrostatic capacity being essentially the same as in the other.

Thus we have in the cable of 1865, as the total resistance to conduction, about 7650 ohms; as the total resistance of the insulator 1,505,000 ohms; as the total electrostatic capacity about 670·4 farads. In the cable of 1866 the total resistance is about 7270 ohms; the total insulation 1,316,000 ohms; the total electrostatic capacity 654·5 farads.

The battery employed by the telegraph company was composed of what are known as Minotti's cells; these being a modified form of Daniell's, in which the zinc rests upon a column of wet saw-dust at the bottom of which is a layer of sulphate of copper, and a copper disk being at the base of all. My friend, Mr. M. G. Farmer, to whom I applied for information, found by experiment the electromotive force of one of these cells to vary from 0·75 to 0·95 volt, averaging 0·84: while the average of four Daniell's cells of ordinary construction gave 0·923 volt. Hence he estimates that, after the full strength of the current is developed, one cell should give, upon one cable with earth-connection, about 110 farads in a second.

The experiments made for measuring the velocity of signals it will be well first to describe in their regular order.

On the night of November 1, the first essays were made, after the use of an electro-magnet had proved hopeless; but owing to numerous difficulties incident to first trial, only a few signals were exchanged. These were made by employing a battery of twenty cells at Valencia, having its positive electrode to the cable of 1866, while the two cables were connected at Newfoundland without battery, and the signals thence were given by alternately breaking and closing the circuit. In the first set no communication was made with earth; 18 signals from Valencia, and 7 from Newfoundland being recorded at both stations. In the second the zincode of the battery was connected with the ground as well as with the cable; and of the signals thus given, 13 from Valencia and 3 only from Newfoundland were thus recorded.

Valencia.

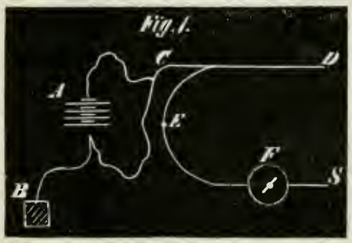


Fig. 1.

Cable of 1866

Cable of 1865

Newfoundland.

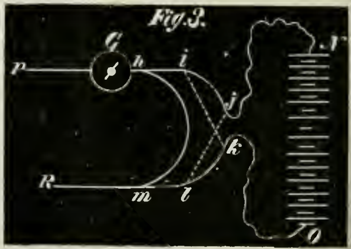


Fig. 3.

On November 10, the first two series of experiments were successfully made, as previously arranged in the programme, excepting that during the second series the Newfoundland battery remained without change. Valencia using 4 cells, and Newfoundland 20. On November 16 the last two series were carried out, with 4 cells at each station.

On the 16th, an independent series of experiments was also instituted by causing the cables to be connected without battery at Newfoundland, while signals were given and observed at Valencia, with resistances of various amounts introduced in the circuit, and with variations in the battery power.

The first question to be investigated is, whether the positive and negative signals were transmitted with the same velocity. For deciding this, no knowledge of the actual time of transmission is requisite, but a simple comparison of the records of the same signals at the two stations will afford an answer. This comparison gives us the interval $T—T''$ (the difference of the time indicated at the same moment by the two clocks) diminished by the time of transmission in the case of signals given from Valencia, and increased by this amount for signals from Newfoundland. This interval is a measure of the longitude, uncorrected for clock-errors or for transmission-time; but for our present purpose its absolute magnitude is unimportant, since our inquiry is answered by comparing the results deducted from positive and from negative signals with each other. Any excess of the time consumed in the passage of either class of signals should manifest itself by a superior value in the measures of the temporary clock-difference derived from that class, when the signals are sent westwardly. For eastward signals the reverse holds.

It had been intended, as will be seen from the original programme, to measure the velocity of signals while the batteries at both ends were included in the circuit, as well as when only one was employed; but since the construction of the signal-keys rendered this arrangement difficult, and inconvenient in many respects, the plan was not carried out. [Tabulated results are here given from which the following deductions are drawn.]

It is manifest that if we disregard the signals given from Valencia while the zincode was connected with the ground on the 10th November, all the differences are of an order of magnitude which justifies the assumption, already probable from theoretical consideration, that the positive and negative signals travel with equal velocity under the same circumstances. This assumption I will therefore make, postponing any remarks concerning the discordance manifested on the 10th November.

The speed of the two kinds of signals being thus taken as the same under similar circumstances, the time required for their transmission is easily deduced, being one-half the difference between the measures of longitude as derived from the records at the respective stations. The weak point in our determination is, of course, the absence of any automatic record of signals received, but the considerations already presented in the chapter on Personal Error in Noting signals afford ground for confidence that the uncertainty here introduced is comparatively small, and that the aggregate personal error of the two observers is very close to $0^s.606$. This value is adopted in the present investigation, and all the measurements hereinafter recorded, with which this personal error is merged, have been corrected by deducting this quantity. [Several tabulated series of results for time of transmission here follow.]

Let us now consider the experiments made without any earth-connection whatever, and first those of November 5 and 16, on which occasions the battery-power at the two stations were the same. Each station sent signals with a battery of 3 Minotti's cells on the 5th, and 4 on the 16th, receiving them with its battery disconnected. The circumstances at the two stations were as nearly identical as possible, and the mean interval consumed in the transmission of the signals appears to have been $0^s.29$ on the former and $0^s.26$ on the latter occasion.

With a battery of 3 Minotti's cells, each possessing a tension of 0·84 of a volt, and incapable of generating more than 110 farads to the second when circuit was made through earth and one cable only, the maximum permanent current would not exceed 168 farads in the joined cables, and to develop nine-tenths of this current more than 1¼ second would be needed. With 3 Daniell's cells the maximum current would not exceed 185 farads. Assuredly we cannot suppose that in the lapse of three-tenths of a second, when not more than one-seventh of this current had been developed at the farther station, this battery could have charged the two joined cables, each of which possessed an electrostatic capacity of more than 650 farads. Hence the impulse upon which the transmission of the signal depends must have been propagated along the conductor by some other means than by charging its successive parts electrically; *i. e.*, fully, and in the ordinary sense of this expression. The 30 farads, more or less, which could have been generated before the signal arrived at the distant extremity of the cables, would have been consumed in charging the first six or seven hundredths of the conductor.

During my stay in Valencia, messages were effectually and distinctly transmitted in each direction by the use of an electromotor formed by a small percussion-cap containing moistened sand, upon which rested a particle of zinc. The current here evolved could scarcely have amounted to more than six or seven farads, so that nearly two minutes would have been requisite for charging one cable; yet the transmission-time was certainly small, although it was not definitely measured.

The experiments without earth-connection on November 6 and 9, differed from those of the 5th and 6th, only in that the Newfoundland battery consisted of ten cells instead of the same number as was employed at Valencia. The mean times of transmission were respectively $0^{s}\cdot25$ and $0^{s}\cdot24$, indicating an increase of speed with the increase of electromotive power. And, so far as the experiments on these four days are concerned, we might infer that on the complete metallic circuit formed by the two cables, the time for transmitting the signals through about 3475 kilometers, or 2160 statute miles, was not far from $0^{s}\cdot29$ for a battery of 3 cells, $0^{s}\cdot26$ for one of 4 cells, and $0^{s}\cdot215$ for one of 10 cells.

On the other hand, the average transmission-time for signals sent by a current induced in a single cable, by means of a "condenser" with a battery of 10 cells, was $0^{s}\cdot31$ on the 25th, and $0^{s}\cdot34$ on the 28th October; the mean interval for these two days being $0^{s}\cdot328$. Each of the condensers used possessed an electrostatic capacity of about 20 farads; so that with a tension of 10 cells, or 8·4 volts, their capacity would be not far from 168 farads, or equal to that of about 590 miles [945 kilometers] of cable—in other words, a little more than one-quarter of the capacity of one whole cable.

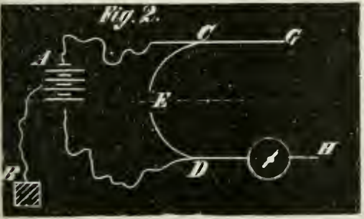
On November 16th all the arrangements seem to have been correctly made, each battery consisting of 4 cells, and the earth-connections at both stations being made with the zincodes in the second experiment, and with the middle of the batteries in the third.

In the former case, all the positive signals found earth at the other extremity of their respective cables without affecting the second cable at all, and therefore without manifesting themselves upon the galvanometer at the distant station; while negative signals, which differed from the positive ones only by the interchange of the cables used for the respective electrodes, were of course received and recorded. Thus we have on this occasion only the "negative" signals; *i. e.*, those in which the platinodes went to the cable of 1866 at Valencia, and to that of 1865 at Newfoundland.

In the latter case the effect of the arrangement would be to substitute two circuits (each consisting of one cable with two cells at each extremity and earth connections), for the one circuit, formed by a cable with four cells at the signal-giving station and with earth-connections; were it not that a very small portion of each of the two first-named circuits is common to the two, being formed by the piece of metal which unites the short circuit of the local battery

Valencia.

Fig. 2.

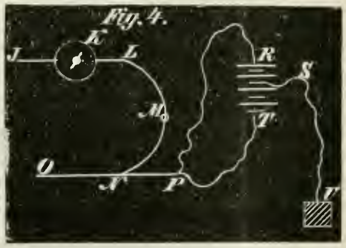


Cable of 1866

Cable of 1865

Newfoundland.

Fig. 4.



with the connected or "looped" cables. This will be readily seen from the diagram, which represents a positive signal from Valencia. Both sets of signals from Valencia were received at Newfoundland; but, contrary to my expectations, only two of the ten positive signals from Newfoundland were perceptible upon the Valencia galvanometer, and these were but weakly indicated, the needle being much agitated.

The results of the recorded signals give $0^{s}{\cdot}26$ as the transmission-time through one cable with earth-return, when the ground-connection was made with the zinc, and $0^{s}{\cdot}27$ when it was made with the middle of the battery; the former corresponding to the use of four cells, at one station only, and the latter to two cells at each station.

Passing next to the consideration of the velocity of signals given by closing and interrupting the circuit, which for convenience we will call "make-circuit" and "break-circuit" signals, we have some data for the investigation from the first and third series of experiments. For the first series the battery was at Valencia, and the signals from Newfoundland were necessarily given by making and breaking the circuit for the battery at the other station, or, in the language of telegraphers, sending against the current. For the third series, the inverse was the case, and the Valencia signals were sent by means of the current from Newfoundland. In both instances the signals from the battery-station were given in the usual way by the alternation of opposite currents. That such an arrangement was ill adapted for any important electrical investigation is very palpable; but such few experiments as were made were of course entirely subordinate to the object of our expedition, and were, as will be seen from the programme, very roughly indicated in advance. The totally different character of the methods and appliances from those which had come within the previous experience of our longitude parties, as well as the very different nomenclature, rendered telegraphic instructions difficult, ambiguous, and, as the event proved, often ineffective. The circumstances under which our few simple trials were made were embarrassing, in spite of the cordial interest and friendly aid of the telegraphic staffs on both sides of the ocean. The cables were in continual requisition for commercial purposes, although all facilities were accorded which I could conscientiously ask. It nevertheless appeared desirable to make such few essays at measuring the time of transmission as opportunity conveniently allowed, in the hope that something of interest might prove deducible. And it will be perceived that our own experience could not be rendered available at the time, inasmuch as all inferences must be derived from the measurement and collation of chronographic records, which could only be brought into juxtaposition by some 3000 miles of transportation. * *

The results of experiments bearing upon the question of relative velocity in "make-circuit" and "break-circuit" are then given, as well as a series of tables, which lead to the conclusion that in general a longer time was required for the transmission of signals after an interval of ten seconds than after an interval of five seconds. In those cases where no earth-connection existed, and the signals were alternately positive and negative, the cable was meanwhile assuming its electrical equilibrium, so that a positive signal was transmitted more rapidly through the conductor when it was affected with a larger amount of negative electricity, and a negative signal more rapidly through a conductor containing more positive electricity. This affords new testimony to the erroneous character of the supposition that the conductor must be charged through any portion of its length, in order to transmit a signal beyond this portion.

As showing the continued existence of currents (doubtless engaged in establishing equilibrium) during the intervals between the signals, it may be of interest to mention that on one occasion when the two cables had been joined at Heart's Content, without battery, and while the Valencia battery had been temporarily disconnected, signals from Newfoundland were distinctly received. They were weak, and the deflections of the needle were scarcely one-fifth as large as usual, yet they were none the less distinct, and a complete set of signals, ten in number, at proper intervals and preceded by a "rattle," was recognized at Valencia. No other record of them was made, than the fact of their transmission by alteration of the make-circuit and break-circuit signals, although no battery had been connected with the cable for several minutes.

(To be continued.)

SPECTROSCOPIC OBSERVATIONS OF THE SUN.

By J. Norman Lockyer, F. R. S.

[Abstract of paper read before the Royal Society.]

The author first referred to several new facts of importance as follows:

"I. The extreme rates of movement in the chromosphere observed up to the present time are—

Vertical movement . . .	40 miles a second.
Horizontal or cyclonic movement	120 "

"II. I have carefully observed the chromosphere when spots have been near the limb. The spots have sometimes been accompanied by prominences, at other times they have not been so accompanied. Such observations show that we may have spots visible without prominences in the same region, and prominences without spots; but I do not say that a spot is not accompanied by a prominence *at some stage of its life*, or that it does not result from some action which, in the majority of cases, is accompanied by a prominence.

"III. At times, when a prominence is seen bright on the sun itself, the bright F line varies considerably, both in thickness and brilliancy, within the thickness of the dark line. The appearances presented are exactly as if we were looking at the prominences through a grating.

"IV. Bright prominences, when seen above spots on the disk, if built up of other substances besides hydrogen, are indicated by the bright lines of those substances in addition to the lines of hydrogen. The bright lines are then seen very thin, situated centrally (or nearly so) on the broad absorption-bands caused by the underlying less-luminous vapors of the same substances.

"V. I have at last detected an absorption-line corresponding to the orange line in the chromosphere. Father Secchi states* that there is a line corresponding to it much brighter than the rest of the spectrum. My observation would seem to indicate that he has observed a bright line less refrangible than the one in question, which bright line is at times excessively brilliant. It requires absolutely perfect atmospheric conditions to see it in the ordinary solar spectrum. It is best seen in a spot-spectrum when the spot is partially covered by a bright prominence.

"VI. In the neighborhood of spots the F bright line is sometimes observed considerably widened out in several places, as if the spectroscope were analysing injections of hydrogen at great pressure in very limited regions into the chromosphere.

VII. The brilliancy of the bright lines visible in the ordinary solar spectrum is extremely variable. One of them, at 1871·5, and another, at 1529·5 of Kirchhoff's scale, I have detected in the chromosphere at the same time that they were brilliant in the ordinary solar spectrum.

VIII. Alterations of wave-length have been detected in the sodium, magnesium, and iron lines in a spot-spectrum. In the case of the last substance, the lines in which the alteration was detected were *not* those observed when iron (if we accept them to be due to iron alone) is injected into the chromosphere.

"IX. When the chromosphere is observed with a tangential slit, the F bright line close to the sun's limb shows traces of absorption, which gradually diminish as the higher strata of the chromosphere are brought on to the slit, until the absorption-line finally thins out and entirely disappears. The lines of other substances thus observed do not show this absorption.

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* *Comptes Rendus*, 1869, 1 sem. p. 358.

"X. During the most recent observations, I have been able to detect traces of magnesium and iron in nearly all solar latitudes in the chromosphere. If this be not merely the result of the good definition lately, it would indicate an increased general photospheric disturbance as the maximum sunspot period is approached. Moreover, I suspect that the chromosphere has lost somewhat of its height."

The author appends a list of the bright lines, the position of which in the chromosphere have been determined absolutely, with the dates of discovery, remarking that in the case of C and F his observations were anticipated by M. Janssen.

Hydrogen.

C.	October 20, 1868.
F.	October 20, 1868.
near D.	October 20, 1868 *
near G.	December 22, 1868.
h,	March 14, 1869.

Sodium.

D.	February 28, 1869.

Barium.

1989·5†	March 14, 1869.
2031·2	July 5, 1869.

Magnesium and included line

b^1 b^2 b^3 b^4	February 21, 1869.

Other Lines.

Iron	1474·	June 6, 1869.
?	1515·5.	June 6, 1869.
Bright line	1529·5.	July 5, 1869.
?	1567·5.	March 6, 1869.
?	1613 8.	June 6.
Iron	1867·0.	June 26.
Bright line	1871·5.	"
Iron . . .	2001·5.	"
?	2003·4.	"
? band or line near black line, very delicate . . .	2054·0.	July 5.

[* *Hydrogen* ?—*G. G. S.*]

† This reference is to Kirchhoff's scale.

Other lines besides these have been seen at different times; but their postions have not been determined absolutely.

The author points out that taking iron as an instance, and assuming that the iron lines mapped by Angström and Kirchhoff are due to iron only, he has only been able, up to the present time, to detect three lines out of the total number (460) in the spectrum of the lower regions of the chromosphere,—a fact full of promise as regards the possible results of future laboratory work. The same remark applies to magnesium and barium.

The paper then proceeded as follows:—

"Dr. Frankland and myself have determined that the widening out of the sodium-line in the spectrum of a spot which I pointed out in 1866, and then stated to be possibly an evidence of greater absorption, indicates a greater absorption due to greater pressure.

"The continuous widening out of the sodium-line in a spot must therefore be regarded as furnishing an additional argument (if one were now needed) in favor of the theory of the physical constitution of the sun first put forward by Dr. Frankland and myself—namely, that the chromosphere and the photosphere form the true atmosphere of the sun, and that under ordinary circumstances the absorption is continuous from the top of the chromosphere to the bottom of the photosphere, at whatever depth from the bottom of the spot that bottom may be assumed to be.

"This theory was based upon all our observations made from 1866 up to the time at which it was communicated to the Royal Society and the Paris Academy of Sciences, and has been strengthened by all our subsequent work; but several announcements made by Father Secchi to the Paris Academy of Sciences and other learned bodies are so opposed to it, and differ so much from my own observations, that it is necessary that I should refer to them, and give my reasons for still thinking that the theory above referred to is not in disaccord with facts.

"Father Secchi states that the chromosphere is often separated from the photosphere, and that between the chromosphere and the photosphere there exists a stratum giving a continuous spectrum, which he considers to be the base of the solar atmosphere, and in which he thinks that the inversion of the spectrum takes place.

"With regard to the first assertion, I may first state that all the observations I have made have led me to a contrary conclusion. Secondly, in an instrument of comparatively small dispersive power, such as that employed by Father Secchi, in which the widening out of the F line at the base of the chromosphere is not clearly indicated, it is almost impossible to determine, by means of the spectroscope, whether the chromosphere rests on the sun or not, as the chromosphere is an envelope and we are not dealing merely with a section. But an instrument of great dispersive power can at once settle the question; for since the F line widens out with pressure, and as the pressure increases as the sun is approached, the continuous curvature of the F line must indicate really the spectrum of a section; and if the chromosphere were suspended merely at a certain height above the photosphere, we should not get a widening due to pressure; but we always do get such a widening.

"With regard to the second assertion, I would remark that if such a continuous-spectrum-giving envelope existed, I entirely fail to see how it could be regarded as a region of selective absorption. Secondly, my observations have indicated no such stratum, although injections of sodium, magnesium, &c., into the chromosphere not exceeding the limit of the sun's limb by 2″ have been regularly observed for several months past. To-day I have even detected a low level of barium in the chromosphere not 1″ high. This indicates, I think, that my instrument is not lacking in delicacy; and as I have never seen anything approaching to a continuous spectrum when my instrument has been in perfect adjustment, I am inclined to attribute the observation to some instrumental error. Such a phenomenon might arise from a local injection of solid or liquid particles into the chromosphere, if such injection was possible. But I have never seen such an injection. If such an occurrence could be observed, it would at once settle that part of Dr. Frankland's and my own theory, which regards the chromosphere as the last layer of the solar atmosphere; and if it were possible to accept Father Secchi's observation, the point would be settled in our favor.

"The sodium experiments to which I have referred, however, and the widening out of the lines in the spot-spectra, clearly indicate, I think, that the base of the atmosphere is below the spot and not above it. I therefore cannot accept Father Secchi's statement as being final against another part of the theory to which I have referred—a conclusion which Father Secchi himself seems to accept in other communications.

"Father Secchi remarks also that the F line is produced by the absorption of other bodies besides hydrogen, because it never disappears. This conclusion is also negatived by my observations; for it has very often been observed to disappear altogether and to be replaced by a bright line. At times, as I pointed out to the Royal Society some months ago, when a violent storm is going on accompanied by rapid elevations and depressions of the prominences, that there is a black line on the less refrangible side of the bright one; but this is a phenomenon due to a change of wave length caused by a rapid motion of the hydrogen.

"With regard to the observation of spot-spectra, I find that every increase of dispersive power renders the phenomenon much more clear, and at the same time more simple. The selective absorption I discovered in 1866 comes out in its most intense form, but without any of the more complicated accompaniments described by Father Secchi. I find, however, that by using three prisms this complexity vanishes to a great extent. We get portions of the spectrum here and there abnormally bright, which have given rise doubtless to some of the statements of the distinguished Roman observer; but the bright lines, properly so called, are as variable as they are in any other part of the disk, but not much more so. I quite agree that the 'interpretation' of sun-spot phenomena to which Father Secchi has referred,* which ascribes the appearances to anything but selective plus general absorption, is erroneous. But as I was not aware, that it had ever been propounded, I can only refer to my own prior papers in support of my assertion which were communicated to the Royal Society some three years ago."

"Researches on Gaseous Spectra in relation to the Physical Constitution of the Sun, Stars, and Nebulæ."—Third note. By E. Frankland, F. R. S., and J. Norman Lockyer, F. R. S.

The authors remark that it has been pointed out by Mr. Lockyer that the vapors of magnesium, iron, &c., are sometimes injected into the sun's chromosphere, and are then rendered sensible by their bright spectral lines. (Proc. Roy. Soc., vol. xvii. p. 351.)

2. It has also been shown (1) that these vapors, for the most part, attain only a very low elevation in the chromosphere, and (2) that on rare occasions the magnesium vapor is observed like a cloud separated from the photosphere.

3. It was further established on the 14th of March, 1869, and a drawing was sent to the Royal Society indicating, that when the magnesium vapor is thus injected, the spectral lines do not all attain the same height.

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* *Comptes Rendus*, 1869, I sem. p. 764.

Thus, of the b lines, b^1 and b^2 are of nearly equal height, but b^4 is much shorter.

4. It has since been discovered that of the 450 iron lines observed by Angström, only a very few are indicated in the spectrum of the chromosphere when iron vapor is injected into it.

5. The authors' experiments on hydrogen and nitrogen enabled them at once to connect these phenomena, always assuming that the great bulk of the absorption to which the Fraunhofer lines are due takes place in the photosphere itself.

It was only necessary, in fact, to assume that, as in the case of hydrogen and nitrogen, the spectrum became simpler where the density and temperature were less, to account at once for the reduction in the number of lines visible in those regions where, on the authors' theory, the pressure and temperature of the absorbing vapors of the sun are at their minimum.

6. It became important, therefore, to test the truth of this assumption by some laboratory experiments, the preliminary results of which are communicated in this note.

The spark was taken in air between two magnesium poles, so separated that the magnesium spectrum did not extend from pole to pole, but was visible only for a little distance, indicated by the atmosphere of magnesium vapor round each pole.

The disappearance of the b lines were then examined, and it was *found that they behaved exactly as they do on the sun.* Of the three lines, the most refrangible was the shortest; and shorter than this were other lines *which Mr. Lockyer has not detected in the spectrum of the chromosphere.*

This preliminary experiment, therefore, quite justified the assumption, and must be regarded as strengthening the theory on which the assumption was based, namely, that the bulk of the absorption takes place in the photosphere, and that it and the chromosphere form the true atmosphere of the sun. In fact, had the experiment been made in hydrogen instead of in air, the phenomena indicated by the telescope would have been almost perfectly reproduced; for each increase in the temperature of the spark caused the magnesium vapor to extend further from the pole, and where the lines disappeared a band was observed surmounting them, which is possibly connected with one which at times is observed in the spectrum of the chromosphere itself when the magnesium lines are not visible.

PHOTOGRAPHY IN COLORS.

By Wilhelm Grune.

[In our excellent cotemporary, the *Photographic News*, (London) we find an article entitled "Experiences of an experimentalist," from which we extract the portion bearing upon the above-named subject.—Ed.]

The fact, established beyond a doubt, that chloride of silver under certain conditions is capable of being impressed by colors—which are reproduced by it—of similar tint; and that even iodide of silver has been known, on some occasions, in the wet-collodion process, to evince a similar capacity, induced me to institute an investigation into this interesting matter; and my efforts, although unattended by success, have afforded several practical and interesting lessons.

The several methods already adopted and made known by investigators into this branch of the science I shall assume my readers to be acquainted with, inasmuch as a description of them is to be found in this *Journal*. The best results are obtained by means of silver plates treated with chlorine, but experiments with these plates have been very limited, on account of the expense of the same, and the trouble involved in preparing them. For these reasons I myself was deterred from their employment, and therefore adopted the idea of using for the purpose the very fine metallic film afforded in the wet collodion process. This method, which answers the purpose well, places within the reach of all the power to observe and examine into the impression made by colors upon chloride of silver.

A well cleaned glass plate is coated with collodion and sensitized in the ordinary manner, then exposed to diffused light for a few seconds, and afterwards developed with iron. When fixed and washed, there is present upon the plate a fine precipitate of metallic silver, and if to the developer a few drops of sulphuric acid have been added, the silver assumes a very light tint, and rests upon the collodion film. The plate is dried, and then exposed to chlorine vapor until it has become of a violet tint, a point easily determined by observation through the transparent glass.

My manner of proceeding is to employ a silver plate—prepared as above described by means of the wet process—and to place this in a solution of chloride of iron or chloride of copper, or in a mixture of permanganate of potash and hydrochloric acid. The silver quickly changes into white chloride of silver, which, after washing in water and drying, may easily be colored violet by diffused light. This is subsequently placed under colored glass and exposed in the sunlight, when the colors will be found to be reproduced with much accuracy.

In order to reproduce natural colors with wet collodion, with iodide or bromide of silver, therefore, I have made many experiments, which demonstrate that the problem is, by these means, capable of solution in a very simple manner, as, indeed, all who follow in my footsteps will be able to affirm.

I employ, for the purpose, a camera used in the production of collodion positives, and, in lieu of the negative, place therein a highly colored transparent picture upon a black ground—such as a bunch of flowers, &c.—so that all light which enters the lens passes through the colored plate. With the different collodions and various pyrogallic acid developers in general use plates may, in this manner, be obtained, which, after fixing and drying, show colors, which, if weak, are still very distinct, and which are visible either by transmitted or reflected light. By using collodion containing but a fourth part of the usual iodizing solution, and over-exposing the same, the results are even more marked. Pure bromide collodion also furnishes some very interesting results. By developing with an acid iron solution, very definite colors may be obtained, the red and blue being especially striking.

This research I was reluctantly compelled to discontinue, and very many experiments may still be made before this field of investigation can be regarded as exhausted. Attention to slight details and minute particulars, will, no doubt, be instrumental in bringing about a practical solution of the beautiful problem of photograhing in colors, for an impossibility it remains no longer.

Through the medium of these experiments, I finally acquired an experience which, for other purposes in photography, may possibly be put to some practical use. I became possessed of the idea that, in order to obtain a better result in regard to chromo-photography, it would be well if the colors could be developed at once in the camera by light, as in the case of chloride of silver. This I achieved by changing the general order of the manipulations through which a plate passes before an image is created. Iodide of silver, light, and a reducing agent, are necessary to the production of a photograph: two of these employed together are without effect, but the presence of the third at once developes a picture. In a general way, we employ first iodide of silver, then light, and then the developer or reducing agent; but I altered this order, taking first the iodide, then the reducing agent, and subsequently used the light to bring out the perfect result.

A plate is collodionized and sensitized in the usual manner, treated with a pyrogallic acid and alcohol solution, and then exposed in the camera; a perfectly developed picture is thus obtained, on opening the dark slide, requiring to be fixed.

From this result much may be learnt, for enlargements upon paper by the developement process; and for photographing out of doors this mode of operating would be useful, inasmuch as the fixing of the negatives may be considerably delayed. For cameras which serve at the same time as laboratories, and in cases where it is of importance to watch the gradual action of the light, this modification would also be advantageous. I will, at some future time, come back to this question, in order to discuss it more fully.

OBSERVATIONS ON THE PLANET JUPITER.

By Alfred M. Mayer, Ph.D.

Professor of Physics and Astronomy in the Lehigh University.

Every astronomer who, during this fall and winter, has made careful observations of Jupiter, must have remarked the unusual colors of his disc and belts, and the remarkable forms and mutations which the latter have frequently presented.

The night of Jan. 5, 1870, was astronomically perfect, and definition was so clear and steady that the six stars of the trapezium of Orion, and the companion of Sirius, were readily and continuously seen in our refractor of 6 inches aperture, by Alvan Clark & Sons.

Turning the equatorial on Jupiter—as has been my practice every clear night this season—I was struck with the beautiful definition and steady sharpness of outline of the details of his disc, and especially was my attention riveted on a ruddy elliptical line lying just below the S. equatorial belt. When first it attracted my attention it had advanced on the planet to a distance from the E. limb, about half its major axis. This form was so remarkable that I was at

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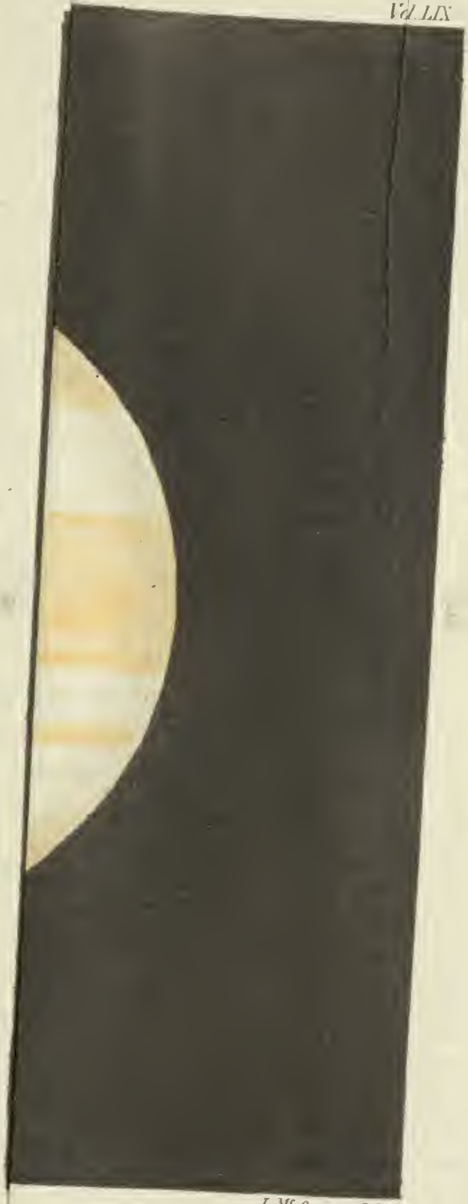

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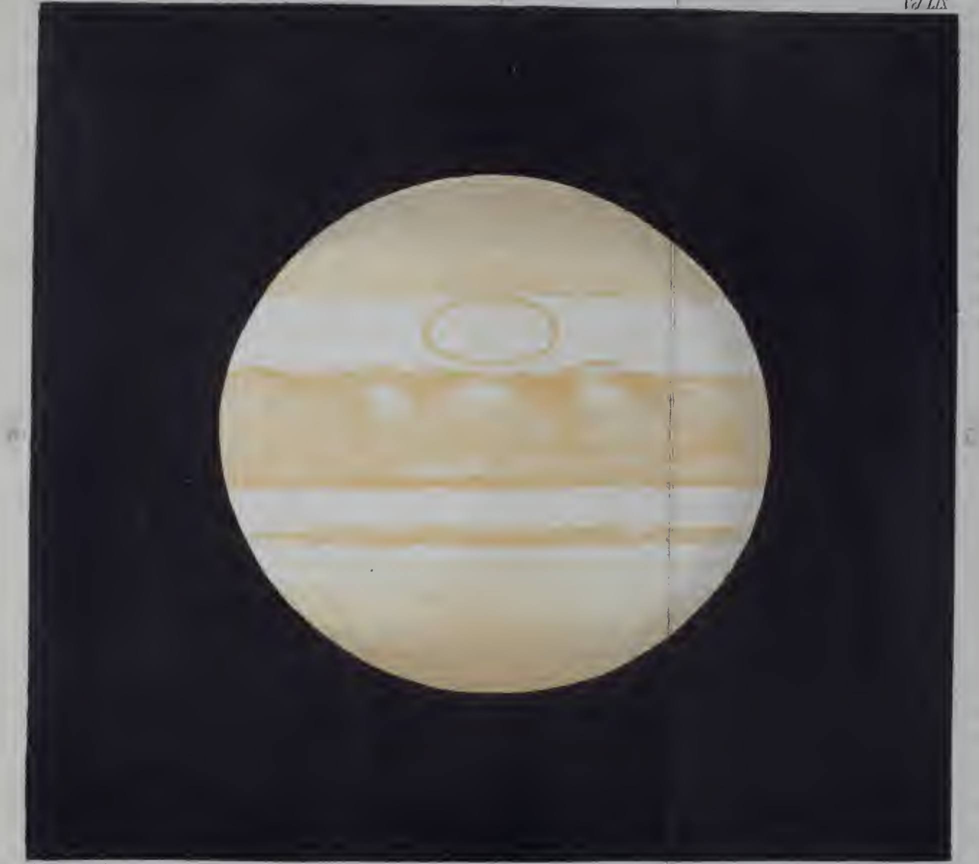

A M Mayer Delt

J M^{c} Guigan Lith

JUPITER.

As seen Jan 5th 1870 at the Sayre Observatory
Lehigh University

first distrustful of my observation; but, keeping my eye steadily upon it I perceived that the ellipse became more and more distinct as it advanced towards the centre of the disc, and that it preserved the same distance from the sharp markings of S. belt which it had when first it caught my eye. Its form, size, color and intensity of tint are correctly represented on the chromo-lithograph as it appeared at 8 h., Bethlehem mean time. I followed this remarkable form until it was about bisected on the W. limb; when it had gradually faded from view.

I am careful in thus minutely stating the circumstances of this observation, for this form (so far as I am aware) has never before been noticed; but so steadily did I see and measure it that I have no fear of having deceived myself as to the accuracy of the observation.

The accompanying lithograph is a faithful copy of a water-color sketch made by me on the following day from drawings at the telescope and from the following micrometric measures.

Polar diameter of Jupiter, mean of 4 measures, . .	42·48″
From N. pole to first belt, " " " . .	13·62″
" " " second belt, " " " . .	17·02″
" " " third belt, " " " . .	26·4″

The polar diameter from above measures is 42·48″; the American Ephemeris gives 42″.

The equatorial diameter of the drawing is 4 inches, which gives for the polar diameter 3·76, adopting a compression of $\frac{1}{17}$. With this diameter of 3·76 inches = 42·48″, the distances of belts 1, 2 and 3 from the N. pole are respectively 1·206 inch, 1·507 inch and 2·34 inches.

The irregular, nearly detached masses forming the S. equatorial dark belt, with their streamers pointing in the opposite direction to that of the planet's rotation, present appearances which incline one to imagine them distinct masses of cloud or colored vapor instead of openings in a cloudy stratum disclosing the ruddy body of the planet. The elliptical form below the S. belt also favors a similar opinion, a view not generally held, and I own difficult to maintain. Sir W. Herschel's explanation of the appearances and nature of the belts is undoubtedly the most satisfactory ever advanced; but we venture to suggest that existing observations on the permanency of position and form of the markings of the belts should be subjected to a careful generalization.

Of the ellipse which appears in the S. bright, cloudy belt, I can offer no explanation. Its major axis to its minor axis is, in its present projection, as 1 to 1·51. If viewed normally (or equatorially) the axes are as 1 to 1·57. Thus, when viewed perpendicularly it still departs largely from a circle-curve. Can we be so bold as to regard it as a great gaseous mass having its origin in the equatorial regions and sweeping S. (as with the terrestrial cyclones of the S. hemisphere), and flattened by the rapid rotation of the planet with an equatorial velocity of 450 miles per minute? The ellipse is flatter on the N. than on the S. side, which fact corresponds with the respective angular velocities of these sides of the ellipse.

The irregular and violent changes which have this winter taken place in the S. equatorial belt seem to give this as the latitude of origin of this ellipse. On the 8th of January, (I read from my observatory note-book,) "the S. border of the southern equatorial band has evidently divided into two." On the 9th "the division of the S. belt has increased rapidly." A drawing, made on the 21st of January (another superb night) shows the S. division of this belt drifted 8° in latidude to the S. of the band which gave it birth. The S. equatorial belt on this date presented the appearance of irregularly massed cumulus clouds forming three distinct aggregations with blunted summits. The N. equatorial belt had the appearance of nimbus clouds from which drooped streamers which extended to a short distance in the direction opposite to the rotation of the planet. These facts are given to show the changes in this belt, and supposing the S. motion of the new belt uniform, it had a motion of 37′ of latitude daily, which equals a daily S. translation of 440 miles.

It is needless to dwell further on the minutiæ of the topography of the planet which the drawings show as they appeared in the 6-inch refractor, at 8 h., January 5, 1870, with a magnifying power of 288.

The color of the planet next demands our attention, and surely no one familiar with the usual tints of the belts and of the general surface can fail to remark the unusual colors which this drawing exhibits.

Jupiter's disc generally is of a light yellow color crossed by belts of a brownish-grey tint, sometimes, though rarely, approaching a rose color. Often the brown is entirely wanting, and the belts are merely dull streaks on a light yellow ground.

We can best convey an accurate conception of the coloring, seen on the 5th of January, by stating the manner in which we tinted the drawing which, when compared repeatedly at the telescope, by myself and others, was found correctly to give the colors and their relative intensities.

The whole disc was first washed over with a slight tint of yellow. The color of the region between the equatorial belts was correctly reproduced by pure yellow mixed with crimson-lake, while the two belts N., and the one S. of the equator were obtained by the same combination of colors, with more crimson-lake added, so as to bring the tint to approach a coppery hue. The polar shadings were correctly given by pure yellow with a slight dash of crimson-lake, which tinting was subsequently overlaid with a very thin wash of light lead color.

The shading shown on the E. limb was distinctly seen and is referred to the fact that Jupiter was nearing quadrature and the shade was part of the slight phase then observed on the planet, and which has been repeatedly seen by me when the planet is in the neighborhood of this position. On Feb. 3, it was yet more clearly marked, the planet then being about three days past quadrature.

I propose extending the series of colored sketches which I have made of Jupiter, and at some future date I will give a continuous history of the changes of form and color observed during the period over which they extend.

It will be interesting to the many engineers who read this *Journal* to know that to one of their number, Robert H. Sayre, Engineer and Superintendent of the Lehigh Valley Railroad, is due the founding and equipment of the observatory of which this drawing is the first published observation, of the many collected during the first year of its existence.

Gilding Machine.—Mr. James Lick, of San Francisco, has recently devised and patented a machine by means of which the surface to be gilded is applied to the gold leaf (instead of the leaf to the surface) while in the book, thus rendering the ordinary cutting and handling of the gold leaf unnecessary.

THE NASCENT STATE.

By M. H. Sainte-Claire Deville.

(Translated for the Journal of the Franklin Institute.)

It is absolutely indispensable to give to every expression used in science a clear and unmistakable definition. The word *state*, as used in chemistry, it is particularly necessary to define, so that it shall not be employed in a vague and uncertain sense from which must necessarily arise always false and often confused ideas. We understand by the expression *state of a body* the collection of all properties with which it is endowed; and this term comprises, among other things, its composition, or the property which it possesses of reduction by analysis into one or more distinct bodies. At present a great number of substances might be mentioned under different heads, which it will be best first to define. A simple body is only characterized by the compounds which it is capable of furnishing, and not as formerly by certain invariable and specific properties.

The great discoverers in modern science since Mitscherlich have, in fact, proved that a simple body may present many allotropic states according to the phraseology of Berzelius. The number of these states is unlimited. Thus we call phosphorus a simple body, which, by combining with oxygen, forms phosphoric acid; but when you study phosphorus itself you see that it possesses various states; a certain number of properties constitute Schrotter's red phosphorus; another group constitute white phosphorus. If you take sulphur of which so many states were observed before those of phosphorus, you recognize in the multiplicity of these different properties several sulphurs, the most interesting of which were discovered by my brother, and is the most convincing argument that could be furnished to the advocates of unity in the composition of matter.

The word state, when it is applied to different manifestations of a compound body, for example, the isomeric state, defines itself like the allotropic state by the assemblage of properties of the compound body under consideration.

What, then, do we mean by the *nascent state* of any body? Can we define this expression exactly, thereby removing from it the vague idea which it now conveys to us? I think not. The nascent state should represent a collection of properties belonging to simple or compound bodies, at the time when they are separated from any combination. It consequently follows that these properties being necessarily unknown, those which we supposed to exist introduced in our explanations either reasoning in a circle or the introduction of an unknown cause.

A body, the moment it comes out of combination, is free or is not free; it cannot be at the same time combined and uncombined, simple and compound; it cannot be *in the process* of birth. We only suppose a nascent state to lend to matter a system of properties arbitrarily assigned so as to explain facts which are not otherwise clear. I will try and demonstrate by experiment and by reasoning that this fiction is useless and consequently hurtful to science.

Usually, the nascent state is brought in to explain phenomena which take place in the interior of liquids or in the exchange of elements effected between materials in solution. Who can say, then, what is the state of aggregation of these elements in similar conditions? Who knows: for example, in a mixture of hydrochloric and nitric acids diffused in a certain quantity of water, what are the bonds which unite together the elements, chlorine, nitrogen, hydrogen and oxygen? In a preceding work (*Sur l'affinite, lecons de la Société*, Hachette), I have shown that what we know of the difference of physical states of the same order no longer permits us to suppose the existence of sulphuric acid and of potash in the solution of sulphate of potash any more than it is to-day possible to confuse red phosphorus with white phosphorus, octohedral or prismatic sulphur and insoluble sulphur. Similar reasoning founded on the disengagement of heat produced by the contact of water with hydrochloric and nitric acid, and on the heat of contraction of these materials at the moment of mixing scarcely allows us to judge of the state of the acids in similar solutions. Since this state is unknown it is not reasonable to assume that it can change in contact with a fourth substance, so as to take, for an indefinitely short time, an equally unknown form, the nascent state. I will develop this idea and show that all these hypotheses are useless, and corroborate it by a series of phenomena which usually belong to the nascent state. I have studied the action of zinc on solutions of sulphuric and hydrochloric acids and of nitric acid, the final result being the production of sulphate of nitrate or of chloride of zinc and the formation of ammonia.

We find in the treatise on chemistry of M. Regnault (Vol. I., p. 173), the following lines which explain satisfactorily to my mind the actual result of the phenomena which I have just mentioned.

When you dissolve zinc in nitric acid diluted with water, the liquid is found to contain a notable quantity of nitrate of ammonia. This formation is explained in the following manner, in dissolving zinc in nitric acid very much diluted with water, there is given off hydrogen gas, and there is formed the nitrate of the oxide of zinc; the reaction is the same as that which takes place when zinc and diluted sulphuric acid come in contact. If we treat, on the contrary, zinc with concentrated nitric acid, the zinc oxidizes at the expense of a portion of nitric acid, it then forms the nitrate of zinc, and it liberates nitrogen and the oxides of nitrogen. Finally, if you treat zinc with partially concentrated nitric acid, the two reactions take place at the same time the zinc is oxidized at the expense of the oxygen of the water and at the expense of the oxygen of a portion of the nitric acid, and it liberates a mixture of hydrogen and nitrogen. These two gases come together in the nascent state in the liquid, they then combine and produce ammonia. A larger quantity yet of ammonia is obtained by dissolving zinc in a mixture of sulphuric acid and dilute nitric acid. You first pour the solution of sulphuric acid on the zinc, and then add drop by drop nitric acid until it ceases entirely to give off hydrogen gas; the zinc continues to dissolve without disengaging hydrogen, which remains in the liquid in the state of ammonia.

We thus establish a great number of similitudes. Some gases which do not combine, when they are mixed in a gaseous state, often combine at the moment when they become free in a solution. We then say they combine in the nascent state.

1st. I will commence by demonstrating that never under any circumstances of surrounding temperature or of concentration can nitric acid give hydrogen, when it comes in contact with zinc, and that the quantity of ammonia produced is absolutely independent of the state of concentration of acid.

I take the nitric acid pure (containing 48·3 per cent. of anhydrous acid), I dissolve it in water, distill, boil and cool it in carbonic acid, so as to drive out as completely as possible all the air dissolved in the liquid. I then introduce some zinc, taking care to prevent entirely the access of air.

The vessel in which I made the experiment being absolutely full and tightly closed, the solution of zinc was effected without there being any visible disengagement of gas; but if I caused the liquid to boil, after removing the zinc a gas becomes apparent; which is the protoxide of nitrogen without the binoxide. Thus a solution containing, for 600 grms. of water, 1·20 grms. of hydrated acid, or 0·58 grm. of anhydrous acid ($\frac{1}{161}$) dissolves the zinc with the production of 23c.c. of protoxide of nitrogen, and the formation of a notable quantity of ammonia.

The protoxide thus obtained may easily contain a little nitrogen but does not retain any trace of hydrogen.

In putting in contact with the zinc a liquid containing 20 grms. of hydrated acid (or 9·66 grms. of anhydrous acid) mixed with 800 parts of water ($\frac{1}{41}$) it produces on boiling, beside nitrate of zinc and nitrate of ammonia, 420 cc. of a gas containing the following elements.

Binoxide of nitrogen	58·8
Protoxide of nitrogen	7·6
Nitrogen	30·2
(Accidental) oxygen	3·4
	100·0

In these experiments, and in others more numerous, which I reserve for a detailed memoire, I have not been able to find even a trace of hydrogen.

No experiment permits us as yet to determine the heat caused by the combination of nitrogen with oxygen corresponding to the formation of an equivalent of dilute nitric acid. The experiments that I have just described authorize us to conclude that this quantity of heat is less than 34·462 heat-units, the combining heat of an equivalent of hydrogen with an equivalent of oxygen.

M. Favre's works teach us that the heat necessary to transform an equivalent of dilute nitric acid into binoxide of nitrogen and oxygen is equal to 20·655 heat-units, a much less number than 34·462 heat-units, which are necessary to decompose an equivalent of water. This explains how the oxydation of zinc is effected entirely at the expense of the elements of nitric acid in this particular case, where the product of the reaction is the binoxide of nitrogen.

2d. We now see what are the circumstances which accompany the formation of nitrate of ammonia in the reaction of zinc on nitric acid.

When you treat zinc with an excess of nitric acid, you obtain in the liquid nitrous acid (AzO^2) a small quantity of the binoxide of nitrogen (because of its solubility), often a large quantity of the protoxide of nitrogen (because of its high coefficient of solubility), a very small proportion of nitrogen, and finally of ammonia. It is clear that none are given off in the state of gas except the insoluble elements in the liquid or these with which it is saturated.

The explanation of all these phenomena can be given without any hypothesis and without the introduction of the idea of a particular or nascent state of *hydrogen* which it is well known is never produced by this reaction.

The disengagement of nitrogen in the reaction of zinc on nitric acid is ordinarily explained by the following formula:

$$5\,Zn + 6Az\,O^5 = 5\,(Zn\,O,\ AzO^5) + Az.$$

For simplicity we assume that a single equivalent of anhydrous nitric acid is decomposed in presence of five equivalents of zinc, so that in the liquid where the nitric acid can be considered as bihydrated $AzO^5\ 2\ H\ O$. Now, if we take out this system of five equivalents of oxygen, it will be:

$$Az\ H^2\ O^2 = \tfrac{1}{2}\,(Az\ O^3\ Az\ H^4,\ O),$$

That is to say, the nitrite of ammonia. Experiment proves that only a part of this nitrogen remains combined with the elements of water, while the other is disengaged under a gaseous form, which accounts for the formation in the liquid of nitrous acid, of nitrogen and of a part of the ammonia.

The disengagement of the protoxide of nitrogen is explained by the formula.

$$4\,Zn + 5\,AzO^5 = 4\,(ZnO,\ AzO^5) + AzO.$$

In simplifying it, one equivalent of anhydrous nitric acid, for instance, is decomposed in the presence of four equivalents of zinc, so that the nitric acid can be considered in the liquid as bihydrated AzO^5, $2HO$, if you take from this four equivalents of oxygen, it then is:

$$Az\ H^2\ O^3 = \tfrac{1}{2}\,(Az\ O^5,\ Az\ H^4\ O).$$

That is to say, the nitrate of ammonia. Experiment proves that only one part of this protoxide of nitrogen remains in combination with the elements of water, the other is disengaged under a gaseous form or remains dissolved, this accounts for the formation of the protoxide of nitrogen, and of a portion of ammonia.

(To be continued.)

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EDITORIAL.

ITEMS AND NOVELTIES

Illinois and Saint Louis Bridge.—[We give below a number of valuable facts which we have collected from late information on the subject of this most interesting and important engineering work, of which we hope to publish before long a full account with drawings.]

On the morning of February 21 the east pier was 83 feet beneath the Mississippi, and had 9 feet 6 inches more to go to reach the bed rock. This rock is 120 feet beneath the ordinary high water level (the city directrix.) The piers will be faced with granite from a point 2 feet below extreme low water. This pier is now built to the granite course and this would have been laid 4 days earlier but for the extreme cold spell, beginning shortly before the above date. About 22,000 tons of stone have been laid in this pier since the 25th of last October. The progress of sinking instead of going on more slowly as the rock was neared, as was generally predicted, has been much more rapid; in the last 24 hours 2 feet and 2 inches were made, whereas the average daily progress during 30 or 40 days in November and December was but a fraction over 8 inches. Within the past week 54 feet 3 inches were made in 3 days, and the average has been about 18 or 19 inches during the past two weeks. This acceleration has been owing to improved construction in sand pumps and better organization of labor, together with a variety of little corrections and improvements suggested by experience. All of the sand and small gravel has been removed with the sand pumps, and these, although entirely novel, have given perfect satisfaction. The larger gravel, excluded from them by strainers, has been thrown into boxes made between the brackets on the sides of the air chamber, and is carried on down with the pier to be used as concrete in filling the chamber when the rock is reached.

The west pier is, to-day, 37 feet 6 inches under water and has yet 28 feet to go before reaching the rock, which is 28 feet higher under it than at the east pier. Its rate of progress is about 22 inches per day. It is built up about 46 feet high from the bottom of the caissons. The progress of the piers would have been much greater, but that interruptions of weather have occured frequently to delay work on both. The appliances for laying masonry are so complete and reliable that it is possible to build 3 feet of each pier in 24 hours. As they are unprotected from the weather the work must be pushed when this will permit it, 2 calcium lights being used on each pier at night. The excavation below goes on night and day without regard to weather. A barge of backing and one of cut stone is kept on each side of each pier (8 barges) when the mason work is progressing, and 12 traveling hydraulic purchases, at each pier, lift and transport the stones and material from the barges on to the piers. This hoisting machinery is on barges or pontoons securely moored on each side of each pier, and, on these, the cement and sand are mixed, and on them the air pumps, water pumps, engines, boilers, &c., are located.

There has frequently been laid, for several consecutive days, an average of 250 cubic yards of masonry (over 500 tons) on one pier, in 24 hours, and this average has been much exceeded, frequently in 10 hours work.

The beauty with which these purchases work and the simplicity of them, have elicited almost universal praise from the numbers of engineers who have witnessed their performance; they are quite novel in design. The air pumps too, although not novel, but of designs matured by Capt. Eads and assistants, have given the utmost satisfaction, which, as all are aware, has not been usually the case with those hitherto used in similar works.

One of the most novel features introduced, and which has proved eminently successful, is that of placing the air locks, for obtaining entrance to the air chamber, in the chamber itself and not above water as has hitherto been the case.

We presume no similar work has ever been executed so rapidly as these two piers, or has been so devoid of mishaps and disasters. This is entirely owing to the care with which all preparations have been made and also on account of their completeness. Mr. Chanute pronounced the outfit to be the best ever possessed by any engineer in America, and he failed to discover anything unnecessary in it. The stockholders are not only much pleased with the regular and rapid progress of the work, but also with the fact that the estimates of its cost have not been exceeded thus far.

The masonry is laid in large blocks of magnesian lime stone which are obtained at the Grafton quarries in beds of from 18 to 30 inches thickness. The granite is from Richmond, Virginia, and more will come from Portland, Maine. It is of bluish gray and in courses of from 13 to 25 inches thickness. Similar granite has been discovered in Missouri, 90 miles distant on the Iron Mountain R. R., and recently a contract has been made to furnish 2,000 cubic yards of it for the bridge.

The men working in the air chamber of the deep pier begin to feel the effects of the great pressure in which they work (now nearly 40 pounds above the normal atmosphere.) They are usually affected (when disabled) by stiffness or loss of the use of the legs, and sometimes of the arms. This passes off in one or two days and leaves no bad effect. They are now only worked two hours at a time and are then relieved by others; those not on duty resting in a comfortable cabin on a barge near by. Much care is used in taking strangers and new workman through the air locks, as the pressure is so great that serious injury to the ears would otherwise occur.

Thus far no loss of life or limb has occurred from failure or breakage of any of the machinery or appliances used in the construction of the piers. Two or three lives have been lost by men falling off of the barges, but none from causes that could be prevented by the engineers or superintendents of the work.

It is well known that the plans for sinking these piers had been fully matured before Capt. Eads ill health compelled him to go to Europe, July, 1868. Before his return, in May last, the associate Chief Engineer, Col. W. Milnor Roberts, (who was elected when Capt. Eads was taken ill) had already advertised for bids for making the pontoons, caissons, &c., required by those plans. Being enabled to witness the actual workings of the *plenum pneumatic* process as practised by the most eminent engineers in Europe, and to study the methods used in the Thames, as well as to converse freely with the best English and French Engineers on the subject, Capt. Eads then became convinced that he could put down these piers more cheaply and safely by the *plenum pneumatic* plan than by any other. He accordingly wrote to Col. Roberts and his chief assistant, Col. Flad, to prepare themselves with every argument they could think of against it, and be ready for a careful and deliberate consultation on this most important part of the undertaking on his return, as he felt satisfied, in his own mind, it was best to adopt this method, and that he should do so unless they could point out some reason overlooked by him. To save all delay he approved of advertising for bids to prepare the plan, &c., (for the original plan he had already devised.) Here turned on the 1st of May, and the work we have given some account of, even to the planning of all the various machinery, caissons, appliances, &c., has been accomplished since that day; for nothing whatever designed for the other method would come in play or be applicable for this. Any one who has gone over the work is satisfied that a very remarkable amount of work has been accomplished since the resumption of operations last summer. Since that time there has also been laid over 2,000 cubic yards of masonry on the west abutment, and 2 ice breakers above the two piers, in the river, have been placed with great labor and a cost of about $30,000. These are a complete protection against ice and drift.

At least two or three thousand persons have visited the air chamber under the east pier, and while care is required in taking persons through, to allow the pressure to come on them gradually, there is scarcely one in a thousand who cannot enter the chamber without any inconvenience whatever. One of the curious and unexpected results encountered under the heavy pressure now found in the caissons, is, that notwithstanding there is such an excess of oxygen, combustion is very imperfect, candles and lamps throwing off so much carbon as to require several expedients to get rid of it. The bright flame anticipated, and confidently predicted, is not to be found.

Back Pressure Break of M. LeChatelier.—A year or two ago a writer in the "*Annales des Mines*" described some experiments making in Spain on a method of economizing the work of trains while descending steep gradients, and while stopping at stations, by merely injecting steam, steam and water, or water alone from the boiler into the exhaust pipe of the engine at the time when the valve was set for reversing the motion, with the engine going forward. The results now arrived at appear to be so satisfactory that upwards of 1800 engines on French Railways are fitted with the apparatus. M. Le Chatelier is Engineer in Chief of Mines, and well known in this country for the complete solution he gave of the problem of balancing the centrifugal forces on locomotives and applying his theory so as to make the engine practically as steady when at its greatest velocity as when at rest. We especially call the attention of railway engineers and managers to this subject. We would have them test for themselves the truth of the following statement of the advantages of the method. 1st. It puts the control of the speed of the train into the hands of the driver of the locomotive himself, giving him a means of instantaneously using all the load on the driving wheels as a break, without danger to himself or stoker, and with little physical effort. 2d. It gives a higher degree of security against collisions and overrunning stations that has hitherto existed, and greatly facilitates all shunting operations. 3d. It economizes rails, by dispensing, in a great measure, with the use of the brakes of the tender and brake vans. 4th. It economizes wheel tires and grease. 5th. It allows the number of brakesmen to be permanently reduced. Except in cases of danger, where a sudden stoppage of the train is necessary, locomotive engines are not generally put into back gear when the train is going forward. Railway engineers and engine-drivers know well the reason why so simple and effective a method of stopping is not always practised. The valves and sliding surfaces difficult of access and repair, wear so rapidly with the hot gases and ashes drawn from the chimney on these occasions through the exhaust pipe, and from their compression afterwards, and consequent heating of the cylinders when being forced into the boiler, that accidents are more likely to occur than to be prevented by reversing the gear on ordinary occasions. Le Chatelier's method removes all these objections. The small quantity of hot water from the boiler sent into the exhaust pipe soon becomes, on account of its high temperature, a wet dense mist or vapor, which is drawn into the cylinder with each stroke of the piston, instead of the hot chimney gasses. This wet steam, besides cooling the cylinder at each stroke to its normal temperature, lubricates the internal moving parts, and thereby prevents their rapid wear ; it at the same time, by the evaporation of its moisture during the compression, fills the cylinder with steam, which acts as a counter pressure and stops the train quickly and without shock. The system came rapidly into use on one of the French lines, which happened to have screw gear for reversing the valve motion, as by it the danger to the engine-driver, of reversing with the regulator open and the train in rapid motion, was avoided. It may come as rapidly into use in this country, in those engines similarly fitted with screw gear, or where Adam's Equilibrium valves are used, with the ordinary reversing lever, as with this valve a boy can change the motion from full forward to full backward gear with the engine at its greatest velocity. Le Chatelier's system removes the chief objection to the general adoption of such valves to locomotives. And by the combination the public will secure greater speed.

Analysis of Meteorites.—Doubts having been expressed as to the meteoric origin of a mass of iron, weighing about three hundred pounds, which was found upon the Collina di Brianza in Lombardy, an analysis has been made by Dr. Haushofer.* The doubt probably arose from a remark made in the original description by Chladni to the effect that Stromeyer had found CO_2 in the mineral. Dr. Haushofer shows that the milkiness which is given, when a portion of the mineral in the form of filings is burnt in oxygen, and the gas passed through lime-water is so excessively small that the amount of Carbonic Anhydride contained in the mineral must be disregarded. The analysis gives Fe, 91·1: Ni, 7·7: P, 0·3: Co, 0·2: CO_2, trace. The Sp. Gr. is 7·596. The Widmann-

*Jour. für prakt. chem. p. 328, 1869.

städtschen figures are brought out strongly on etching the cut faces.

An analysis of the oxidized remains of a meteorite from Cranbourne in Australia, by the same chemist, gives Insoluble Silicates 4·1 : SiO_2, 2·3 : Al_2O_3, 1·5 : Ca, 1·8 : PO_5, 1·4 : Fe_2O_3, 71·1 : NiO, 3·1 : H_2O, 13·7 = 99·0.

The external appearance of the analysed portions is very similar to that of brown clay iron-stone or bog-ore : its meteoric origin is shown, however, by the presence of Nickel. The hardness is about that of feldspar, Sp. Gr. 3·74.

An examination of the minerals resembling Vanquelinite in the Royal Museum at Stockholm, has revealed to A. E. Nordenskjöld the existence of a new mineral, a double salt of chromic and phosphoric acids, for which he proposes the name Laxmannite.* Two analyses give :

	I.	II.
Plumbic Oxide	61·26	61·06
Cupric "	12·43	10·85
Ferric "	1·09	1·28
Chromic Acid	15·26	16·76
Phosphoric "	8·05	8·57
Water	1·31	0·90
	99·40	99·42

and agree with formula, $(\frac{2}{3}\,CuO, \frac{1}{3}\,HO)_3\,PO_5 + 3\,(PbO, CuO)_2\,CrO_3$ The Laxmannite forms crystalline crusts some lines in thickness, or crystalline masses filled with drusy cavities, whose walls are covered with dark green glistening crystals. The cleavage is partly crystalline, partly massive and earthy. The color, dark green to pistachio and greyish green. The crystals are monclinic prisms.

A. R. LEEDS.

Use of a Bell-jar and Beaker with Bunsen's Pump.—The following attachment to Bunsen's pump, which suggested itself some time ago, and of which we subsequently saw a notice in the *Chemical News*, has now been in use for several months, and its merits are such as to deserve more particularly the attention of chemists. Instead of the cumbrous bottle generally employed, the plate of an air pump may be advantageously substituted, and a receiver, with an india-rubber cork, through which the neck of the funnel is passed as represented in the drawing. In order to prevent loss by the bursting of bubbles of air at the end of the tube of the funnel, it is continued low down into the beaker by an india-rubber tube A. The latter can easily be removed at the end of a filtration, and the drops of adhering liquid, washed with water from the spritz, into the filtrate. This simple arrangement obviates the necessity of a transfer from one vessel to another, and permits all the operations of an analysis to be carried on as usual, in beakers. Instead of an air-pump plate, a sheet of glass may be used, and the exhausting tube as well as the funnel in this case must be passed through the tubulure of the bell-jar. A similar arrangement is useful for the dessication of bodies, either alone or with sulphuric acid.

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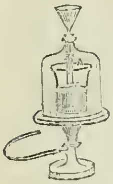
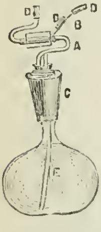
* Ann. de Phys. u. Chem. 136, 299.



Improved Form of Wash-bottle.—The accompanying drawing represents a wash-bottle which I have seen in use abroad, but which I have not seen in text-books or employed at home. The delivery tube A is bent sharply upon itself, and then cut off at a point not quite directly above where it makes the first bend. The jet is bent in the same manner but in a contrary direction, and the two parts are connected by an india-rubber tube. Over this is fitted a short piece of glass tube of such a bore as to fit tightly, yet permit at the same time the jet to be pointed upward, downward or in any direction. In transferring precipitates from one beaker to another, or in washing a precipitate back into a beaker, etc., such a form of wash-bottle is much more convenient than that in common use. B is the entrance tube, C cork tied around the neck of the bottle, *d d d* pieces of india-rubber tubing where the glass tubes, in order to give greater flexibility, are cut into parts. The delivery tube is bent at *e* so as to reach into that corner which is lowermost when the flask is inclined.

ALBERT R. LEEDS.



A Machine for Sewing on the Bottoms of single-soled shoes, commonly called "turns," has been invented by Mr. M. J. Stein, of New York City.

Editorial Correspondence.

PUMPING ENGINES.

To the Editor of the Franklin Institute Journal.

SIR:—I have read the communication from Mr. Fulton, which appeared in the issue of the *Journal* for January, and will do my best to supply the information he solicits, for the benefit of "the authorities of our great cities, to relieve the great anxiety of these gentlemen in all the great municipalities of the land, to economize *in machinery* that the load of taxes upon the people may be light."

Before entering upon this task, however, there is one point to be noticed in the paragraph above quoted, which Mr. Fulton has laid particular stress upon, having italicised it, viz., *economy in machinery.* In regard to that particular, I must state as my honest conviction, that I do not believe that it could possibly be more effectually accomplished than has been done in the engines he refers to, now being erected at the Belmont Water Works—as I perceive each set of cylinders and pumps, are placed at once upon the bare foundations, bed-plates, which the mechanics here have always considered indispensable, are entirely done away with. The whole of the work is singularly simple and plain, with an air of lightness about it quite unusual in such localities, the provisions generally made for taking up the wear of the working parts being considered superfluous, whilst the air-pump buckets, pump-glands, &c., which, according to the custom of this city, are invariably made of brass, are constructed of solid cast iron, ingeniously veneered with that former costly metal. As a proof of the extreme economy *in this machinery*, I would state that each of the 50-inch steam cylinders are firmly secured to the masonry of the foundation by 4 wrought iron bolts of $1\frac{1}{8}$ inch in diameter. If the load of taxes upon the people were in proportion to the economy exercised in the construction of *this particular machinery*, the people have cause to rejoice. In order that the extent of this benefaction may be fully made known and everywhere reported, perhaps Mr. Fulton could give us the amount of their cost (*actual*) and the items, necessarily pertaining to the difficulties attendant upon securing them for this city as a matter of comparison between them and the other pumping engines built here. With this digression I will now turn to the task of answering the queries indicated by Mr. Fulton, which is by no means an easy matter. In the first place, there are but few Cornish engines in this country, and these far apart, built mostly by parties who have never made a speciality of their construction, as is the case in England. It was for this reason that I confined my previous remarks to those built by firms who have followed the business for a century.

The examples I have recited are fair exponents of what the Cornish engine *has* accomplished, and were offered in reply to a statement which appeared in the *Franklin Institute Journal* for January, 1869, page 16, "there is yet another engine, based upon reciprocating parts, without a fly-wheel, which has the capacity of rivaling the Cornish in its best results," referring to the description of engine now being put up at Belmont. Why are these examples not acceptable? In order to ascertain how far this other engine can rival the Cornish in its best results, we must first discover what results have been attained by the Cornish, to make the comparison, tha particular information is what I have supplied in the last November number of the *Journal*, page 311, and that data is the tru standard for comparison. The Cornish engines of this country, fo a variety of reasons, are not equal to those in England. There i no reason why quite as good engines should not be built here, i our engine builders were allowed to turn their attention to tha subject, with full scope to turn out the work in the best possibl manner. But the great question here, unfortunately too often is, not so much who can build the best engines as who will pay th the highest premium for getting the contract. This may be distasteful to some, but it is the glaring fact which strikes at the roo of all our great undertakings. The premium extorted is often s large, that the actual price paid is altogether inadequate to build machine substantial enough to stand the arduous work of pumpin water with a high grade of expansion, which means economy in fue a totally different matter from *economizing in machinery*, a resul following the premium process. I have not been successful in procuring any reliable information in regard to the duty of Cornis engines in Philadelphia. By Cornish engines I mean those working with a beam. At Spring Garden Water Works there is on which has been running for the past sixteen years. But as ther has been in the same house three other engines which were nc

Cornish, and the coal consumed was charged to them all, no reliable continuous duty can be given. The second Cornish engine lately erected at the same works, has not been running long enough to ascertain the precise duty, and the third and last one, lately started at the Roxborough Water Works, has no duty assigned for the same reasons as given for the side lever at Spring Garden Water Works. Experimental duties have no force, and I am not willing to entertain them in this discussion. In regard to other *Cornish engines in this country*, I am under obligations to John F. Ward, Esq., Superintendent of the Jersey City Water Works for a copy of Report for 1869, from which is copied the following:—Pair of Cornish engines, steam cylinders 80 inches in diameter, stroke 11 feet, steam from 25 to 27 pounds, cut-off about 4 feet, diameter of pumps 34⅝ inches, and 34¾, stroke 11 feet, water elevated 160 feet from mean level in pump-well. The results of 18 months' working, ending December 31, 1869, show cubic feet of water pumped 445,242,145, coal consumed in pumping 8,110,274 pounds, for banking fires and other purposes 333,335 pounds. This gives the duty for the whole of that period, viz., 18 months, of 61·5 millions, calculated from the net coal consumed, and a duty of 58 millions from the gross coal consumed. I am also indebted to the kindness of John Whitelow, Esq., Superintendent of the Cleveland Water Works, for a copy of report for the year 1869, from which the following is copied:—Pair of Cornish engines, steam cylinder 70 inches diameter, ten feet stroke, pumps 30 inches, stroke 8 feet 10 inches, working velocity of engines 9 strokes per minute, water elevated 157·5 feet, number of gallons pumped 898,936,425, coal consumed for *all purposes* 2,655,000 pounds. This is equal to a continuous duty for 24 months, of about 50 millions. These engines have been running for the past 13 years. Some remarks are necessary in regard to their performance. The fuel used is bituminous *slack* costing but $2·20 per ton delivered in the boiler room. There are two sets of steam boilers situated upon opposite sides of the engine house, and they are used alternately, one month at a time, a great loss is hereby sustained from the extra amount of fuel required to raise steam from cold boilers. Besides this, the boilers are not properly enclosed to prevent loss of heat by radiation, as is usually done. The duty, therefore, under the circumstances, is remarkable, and they are probably as economical as any others in this country.

At Easton, Pa., single Cornish engine, steam cylinder 50 inches in diameter, stroke 10 feet, pump 18 inches, stroke 8 feet, making from 6 to 7 strokes per minute, elevating the water 244 feet, steam 30 pounds, cut-off at ⅝ of stroke. The amount of fuel reported to be consumed is 100 pounds of chestnut coal per hour. If such is the case, the duty is equal to 94 millions.

As regards the table inserted by Mr. Fulton, copied from "Van Nostrand's Eclectic Magazine," when the subject of the pumping engines for the City of Brooklyn was under discussion. *It amounts to nothing.* The first trial of the Cambridge Duplex was only o 9 hours duration, and the second trial of 14¾ hours. It by no means follows that because a man can walk 6 miles in one hour that he will walk 60 miles in ten hours. There is one noticeable fact which cannot be disputed in this connection. The Duplex engine was *not* adopted by the City of Brooklyn, notwithstanding the resulting opinion of the experts who conducted the experiments This is the more remarkable as that place above all others is where the true character of the engine must have been well known and fully established, it being the very spot where the said engines are built. This reminds me of "some other information, perhaps now forgotten," that in the celebrated trial, with the same kind of engines, at Charlestown, 1867, a duty was recorded of 78,564,150 *i. e.* 266,752,325 gallons of water was raised 147 feet by 416,117 pounds of coal, an unfortunate item of 266,000 pounds of coal were also used, for banking fires, testing engines, boilers, &c., as appeared in a foot-note in small type, ruining the whole calculation. It is not the custom to estimate the duty of pumping engines, by the amount of the combustible element consumed, deducting ashes and clinkers, &c., and I desire it to be particularly understood that we do not expect the forthcoming trial of this other engine to be conducted upon that basis, they should run at least 60 days, and the whole of the coal purchased, and not seen about the works, charged The pump-valves should also be rigidly examined before and afte the trial, to see that none of the springs have come off, and tha they have been cocked up for any length of time, as the water wil no doubt be estimated from the number of strokes indicated by th counter, and there is quite a remarkable difference between th power required to force against the head of water in the rising main, and the release experienced in the water circulating through the pumps.

The comparative merits of Cornish and other descriptions of pumping engines, is a matter that for years has afforded subject for keen discussion between the partizans of the former and others, who periodically appear with some new patent engine or pump, which, naturally enough, they strive to force upon the public notice, and there is no limit to the artifices employed to carry out their designs. This matter has arrived to such a pitch in this country that I find it recorded. An immense *Rotary* pumping engines has lately been put up in a water works in Kentucky. We must therefore not be surprised to find that hereafter economy in fuel must be supplanted by *economy in machinery*, as already pointed out to us by Mr. Fulton, and that in a very short time we shall have such things as bellows pumps and steam syphons introduced into our water works. No difficulty need be apprehended in carrying this into effect if a judicious attention is paid to the premium process. I have, when the opportunity has occurred, compared the arguments adduced, and tested them with the data to be relied upon connected with the several cases which have been brought to my notice, and find it impossible to resist the conviction, that upon the whole, the Cornish engine has always emerged triumphant from such comparisons, both in the item of fuel and necessary repairs. It has besides been much more extensively used than any other description of engine for pumping purposes, and it is not too high a compliment to pay it to state that it has, in all cases, rendered the highest satisfaction. The avidity with which it is invariably selected, as the standard for comparison proves at least that it has attained a high reputation, which is not to be taken away by any indefinite set of experiments, conducted in a bias direction, and possibly advanced as a species of advocacy, which entirely disregards all facts opposed to the schemes of the deponent for the time being.

If we are permitted to select the best engines of their respective classes, we shall not fail to discover, that the advantages are greatly in favor of the Cornish, as explained in my first article on Cornish Pumping Engines, published in this *Journal*, July, 1868. I would simply add, that the single feature of gravity acting in favor of the Cornish engine doing actual work, is quite an obstacle in the way of any other description of engine approaching it in its economical results.

Before this can be done it will be necessary to suspend the attractive power of gravitation, or cause it to act at right angles to the path nature has assigned, Whether this has been accomplished in New York or not, I am not prepared to say, but it is a matter that should be attended to at once, if any hope is entertained of supplanting the Cornish engine, by the machines built there for our water works. Cornish engines, under the worst circumstances, cannot be called uneconomical, whilst with other descriptions of engines there is no fathoming the depth of mechanical degradation to which they descend.

There is probably not a Cornish engine in this country doing a less duty than 40 M, which is far more than the average of the best results obtained from any other description of pumping engines. In the transactions of the society of engineers for 1864, page 87, the comparative performance of a Cornish engine, and another working with a crank, under similar circumstances, and taking steam from the same boilers, was the subject of direct experiment to settle the very point of this controversy. These experiments were conducted at the Ipswich Water Works, the result was a daily duty of 76 M. for the Cornish, and 54 M. for the crank. It must be borne in mind the latter engine was one of the most celebrated makes, and it was firmly expected the Cornish would be vanquished. It is quite possible to dispense with the fly wheel and work double acting pumps, singly or in pairs, such engines, however, possess none of the advantages belonging to the Cornish type. The superiority of the latter is not a mere matter of theory, or any opinion of mine. It is a mechanical fact, that whether we take average, or selected performances, whether we consider the action of the pumping or the independent character of the entire steam engine system, there is but one conclusion to be arrived at, that some men should not be able to understand this is of no importance, the fact will still exist, the conditions of their intellectual capacity or predjudices, leading to adverse conclusions, notwithstanding.

In connection with this same subject, I would state that I have read the article written by Mr. W. H. G. West, upon the performance of a number of steam engines, with a descriptive list as reference. But as these are mostly of the stationary variety and employed in driving elastic loads, I do not propose to be led away by them, from the original subject of this controversy, *i. e.* pumping water.

It may be interesting to be informed of the smallest number of pounds of coal that have, at times, been consumed per horse-power in turning a wheel, driving elastic loads, such as mill shafting, &c., strongly susceptible to continuing momentum. But I utterly fail to see what that has to do with the question of driving the dead load opposed by water when bodily elevated. A matter quite as much to the point would be to institute a comparison between the performance of a race horse and an elephant. I have no doubt it could be satisfactorily shown, that if the velocity of the former were multiplied by the force given out by the extension of the muscles of the slender legs, it would compare very favorably with the prodigious energies exerted by the slow moving mass of the latter quadruped. I would prefer, if agreeable, to stick to the question originally started, and must beg Mr. W. to produce the results of some of his favorite engines pumping water, as an off-set to the list of the duties of the Cornish engines, I supplied in the November number of the *Journal* of last year.

WILLIAM M. HENDERSON.

Philadelphia Hydraulic Works.
March 1, 1870.

NOTE ON A NEW LOCALITY AND COMMERCIAL SOURCE OF THE OXIDES OF NICKEL AND COBALT.

By Chas. P Williams.

Editor of the Franklin Institute Journal.

Dear Sir:—Of the auriferous deposits of Nueva Providencia, Venezuela, thus far opened and worked, the vein known as "La Corina" has been most thoroughly exploited. Operations on it have extended, already, to the depth of upwards of seventy feet, and have developed a vein of about four feet average thickness with a general N. E.—S. W. course and standing at a high angle. The wall rocks are, even to this depth, completely decomposed and converted into clayey masses of various colors (locally used for pigments) but are separated from the compact hard white quartz of the vein by heavy and well marked selvages or seams of a soft black manganiferous substance, resembling, in appearance and physical properties, the variety of wad known as *asbolite*, but differing from that mineral in giving no reactions of water of combination (after being freed from its hygroscopic water by drying at 100° C.) and in showing a very considerable per centage of oxide of nickel. The substance forms, not only the selvages or flucans of the veins, but also the gossan, and fills the seams of the disturbed and shattered portions of the lode, appearing as a cementing material, as it were, of the fractured quartz, and giving to the vein a brecciated structure.

Assay shows it to be quite rich in gold, containing the metal in workable amounts. With hydrochloric acid it is completely decomposed, liberating chlorine with the separation of gelatinous silica. The following is an analysis of the substance (dried at 100° C.) made by Mr. Roberts Le Boutillier, a pupil in my laboratory.

Protoxide of Manganese	46·973	per cent.
Oxygen, in combination with above	7·545	"
Sesquioxide Iron	4·073	"
Alumina	15·934	"
Oxide of Copper	·528	"
Oxide of Cobalt	3·555	"
Oxide of Nickel	10·385	"
Oxide of Zinc	traces.	
Lime	1·605	"
Magnesia	1·653	"
Sicilic acid	8·653	"
	100·264	"

The oxides of nickel and cobalt were separated by means of the nitrite of potassa method. The available oxygen was determined in the usual method for the valuation of manganese ores, that is by means of its conversion into carbonic acid in the presence of oxalate of potassa and sulphuric acid.

This mineral is not confined to La Corina but is so abundantly distributed throughout the gold region of Venezuela that it may ultimately become an important source of raw material for the preparation of nickel and oxide of cobalt, and with this in view the writer makes the notice of its occurrence public. A. B. Garner, Esq., to whom I am indebted for the specimens for analysis as well as for most of the facts with regard to the manner in which they occur, assures me the substance is the common accompaniment and gossan of other auriferous veins of the region.

Yours, &c., CHAS. P. WILLIAMS.

Laboratory, No. 327 Walnut Street,
Philadelphia, February 23d, 1870.

Civil and Mechanical Engineering.

THE THEORY AND PRACTICE OF THE SLIDE-VALVE.

By Thos. Adams, C. E.

Read before the Franklin Institute, May, 1869.*

The Slide-Valve, as at present almost universally used on the Steam Engine, was invented by William Murdock of the Soho Works, near Birmingham, about the year 1784. It was first set to work without either lap or lead, but, subsequently, he added a sixteenth of an inch of lap to give lead for the exhaust, and subsequently, again, he added a sixteenth of lead for the admission, and in that state he left it. And although engineers, since that period, have extended the proportions of lap and lead, yet the primary elements, lap, lead and travel, remain as they left the hands of Watt's companion.

Notwithstanding the enormous amount of power required to work this valve and its appendages, engineers prefer it to any other known form, because of the facilities which it affords for a ready admission of steam, any required amount of expansion, and a liberal lead for exhaust, and requiring no other gear to work it than a rod direct from the valve to the eccentric, thus avoiding complication of parts and ensuring simplicity and certainty of action.

The relief of the slide-valve from the load which its mechanical construction necessarily imposes upon it, has engaged, and in some instances absorbed, for a time, the attention of mechanical engineers. The records of the Patent Office of England alone show that upwards of 500 patents have been taken out for the accomplishment of this object, including, amongst them, many names of the highest distinction known in engineering, and this forms but a fractional part of the number who have otherwise tried and failed. Probably on no portion of the Steam Engine has there been spent more time in study, patents and trials, or have more attempts been made which have proved unsuccessful, than upon the slide-valve. In fact, there is no engineer, of any repute, past or present, who has not devoted some of his time in the endeavor to remove the weight from the back of the valve; but so fickle and deceitful a piece of mechanism has it proved itself to be, that it has hitherto baffled the united skill of all, until, at length, it was considered impossible to produce a frictionless slide-valve. This is sufficient proof that there must have been some unknown cause, apart from its mere mechanical construction, operating upon the valve to prevent the successful accomplishment of an effect so unanimously desired. That this was so, there is now no longer any reason to doubt. For, upon principles hitherto unknown to engineers, a slide-valve can be constructed which will move as easily with steam of any pressure on as off, be perfectly steam-tight, and bear on the face of it the impress of simplicity.

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* This paper is now just received from the author, which fact explains the delay in its publication.—Ed.

To the accomplishment of this task the author set himself about nine years ago, and he has labored incessantly in designing and making experiments during the whole period, from that date to the present. For nearly four years of that time the problem completely baffled him, setting all attempts at defiance, and at length compelled him to leave the beaten path of engineers and to seek a new field of discovery in the relation of surface to pressure. For, it has been discovered, that within certain limits of pressure, neither the file, nor the scraper, nor pumice stone, nor the oil stone, will get up two surfaces of metal sufficiently fine to shut out steam. The steam says "I am master and in I will go between your surfaces, and I will not come out until you apply a force greater than the area of the surface in contact multiplied by the pressure." This is the fundamental principle, the discovery of which immediately produced a practically frictionless slide-valve.

All engineers are of one accord in ascribing the loss of a large amount of power in working the slide-valve, but there is a large diversity of opinion as to what that amount of power is, solely because there is no correct data from which they may calculate it as they do other losses of power. A paper on the slide-valve would be incomplete did it not bring within its range, the consideration of two questions:—First,—What is the magnitude of the evil of which it complains, and, secondly, what is the remedy for that evil. And in setting about such a task the first thing to be done is to ascertain the co-efficient of friction under the circumstances attending its practical application, and by that ascertained factor to calculate the amount of work performed by the force expressed by the co-efficient of friction passing through space, and by the time in passing through that space, and upon the principle of work done find the proportion which that power bears to the mean power of the piston.

With these preliminary remarks we will proceed with the investigation of the subject, and first,—What is the amount of power absorbed in working the slide-valves and appendages of the steam engine?

For that purpose we select (Plate I) where Fig. 1* represents the ordinary valve, as applied by Mr. William Buchanan, master mechanic of the Hudson River Railway, to an Express Engine named W. H. Vanderbilt, which is one of the most improved type of the American locomotive, so far as the distribution of the steam is concerned, as the following dimensions and investigation will show. Diameter of driving wheel $5\frac{1}{2}$ feet, speed of engine 30 miles an hour. Diameter of cylinder 17″, stroke 24″, pressure 120 pounds. Exhaust port $2\frac{3}{4}''$, admission port $1\frac{1}{8}''$, inside bar 1″, outside bar $2\frac{1}{4}''$, length of port 16″ bar on end of ports 1″, outside lap $1\frac{1}{8}''$, inside lap $\frac{1}{16}''$, depth of exhaust cavity of valve $2\frac{1}{4}''$, travel of valve $3\frac{1}{4}''$ in working position.

Fig. 1 is a section of this valve laid in middle position over the ports. Fig 2 is a plan of the same. The outer and inner edges of the valve, by their crossing the outer and inner edges of the bars, determine the distribution of the steam. If, then, we let fall lines M N, &c., from the outer and inner edges of the valve in this position and on the points E E′ E″ E‴ with half the travel of valve as radius describe semi-circles equal to travel of valve, divide these semi-circles into ten equal divisions, corresponding to the ten equal divisions on the indicator diagram Fig. 3. Let the pressure on the back of the valve be represented as positive pressure, and those on the face as negative pressures, measure the horizontal distances from each division to the edge of port or bar, and find what section of surface of valve face is exposed to negative pressure, that section multiplied by the length of port and by the corresponding pressure on the diagram will give the negative force, which taken for the ten divisions and their sums added and divided by ten to give their mean, and that sum subtracted from the total positive force will leave the force available for friction, which, multiplied by the coefficient of friction and by the space passed through in feet per minute by the valve, and divided by 33,000, will give the horse-power required to work the valve.

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* The plates, or drawings, referred to have not been sent to us by the author. We expect them, however, shortly, and hope to have them engraved and published in the next number.—(Ed.)

Fig. 3 is a diagram representing the power developed by the piston where B A is the scale of pressure, A the point of admission, S the point of suppression, E the point of exhaust, and C the point of compression.

Table I contains negative forces taken off the diagram (*indicator*) corresponding to the ten positions of the valve represented by the ten equal divisions of the semi-circle, each division corresponding also with its relative division on the diagram, from which the pressures are all taken. The first column is the number, the second is the sectional breadth, the third is the length in inches, the fourth is the pressure in pounds per square inch taken from the diagram, except when the valve is over the extreme end bar, and then the boiler pressure of 120 pounds is taken. The fifth column is the 2d, 3d and 4th multiplied into each other, which, being done for the four edges of the valve, their sum is taken, and that divided by ten to give their mean negative force, which being subtracted from the total positive force will leave the force available for friction, thus:—

The last column is the back pressures giving a mean of 7·8 pounds The second last is the propelling pressures from which subtracting the back pressure, gives the mean propelling force of 72·6 pounds. The third last column is the number of square inches bearing on the cylinder face, giving a mean of 69·5, and the positive force available for friction divided by the number of square inches of bearing surface, gives the pressure per square inch of the valve on the cylinder face, and from which we get the co-efficient of friction, thus:—

$\frac{17695}{69{\cdot}5} = 255$ pounds per square inch, and this, and not the boiler pressure of 120 pounds, is the pressure from which we get a co-efficient, and with cast-iron valve, on cast iron cylinder, it gives a co-efficient of ·28. Then we have

$\frac{3072 + 2603 + 8937 + 8241}{10} = 2285$ equal mean negative force,

$18 \times 9{\cdot}25 \times 120 = 19980 - 2285 = 17695$ equal force available for friction. $\frac{17695 \times {\cdot}28 \times 88}{33000} = \frac{4955 \times 88}{33000} = \frac{436005}{33000} = 13{\cdot}313$, which multiplied by 2, for double stroke, gives $26{\cdot}626 =$ H. P. of values.

$4956 \times {\cdot}15 = 743$, then $\frac{743 \times 643}{33000} = 14{\cdot}47$, which doubled, gives

28·94 = H. P. of both eccentrics. $\frac{227 \times 72 \times 648}{33000}$ = 322 which also doubled, gives 644 = H. P. of both cylinders, and $\frac{644 - 55·6 \times 100}{644}$ = 91 (nearly) per cent. and 180 — 91 = 9 full per cent. for the friction of valves and eccentrics.

Space swept through by piston per minute, 648 feet,
" " " valve " 88 "
" " " periphery of eccentric per minute 643 ft.

The following is the mode of calculating the friction of eccentric.

Let C be the centre of rotation, and A the centre of formation. B, D, E the periphery of the eccentric sheath. B, E, is the plane of the periphery, and B E multiplied by *b e* is the bearing surface of eccentric sheath and strap, and the position load on the valve available for friction, multiplied by the co-efficient of friction, is equal to the direct pull on the valve spindle, and the pull on the spindle divided by the number of square inches in the eccentrics plane, is equal to the load per square inch on eccentric and from which we get the co-efficient ·15. That multiplied by the space passed through by the periphery of the eccentric in feet per minute, and divided by 33,000 will give the horse-power required to work the eccentrics. Thus, let B E equal 15 and *b e* equal 2·75, then 15 × 2·75 = 41·25 = square inches in eccentric plane $\frac{4956}{4125}$ = 120 pounds per square in.

The combined friction of the valves and eccentrics worked by link motion is practically a constant quantity in all positions of gear, the speed remaining constant, but the power developed by the piston is changed with a change in the position of gear, and thence it follows that the percentage of the power of working the valves and eccentrics varies with the position of gear, being least in full gear and greatest in mid-gear, varying with the engine before us from a minimum in full gear of about 6½ per cent. to a maximum in mid-gear of about 15 per cent.

These percentage bear the same relative value to the marine and stationary engines, whose dimensions are all proportional.

The Remedy.

To remove this load from the back of the valve and so save this per centage to the users of steam power, has been the study and anxious desire of all intelligent engineers, but though many have tried, and tried often, yet only failure to many, and that often, has been the result, for this one cogent reason: They were not acquainted with the forces involved. One class of engineers say the pressure is equal to the whole area of the valve, another, it is equal to the area of the valve, minus the area of the two admission ports, and another, the most numerous of all, say, with all the confidence of right, that it is equal to the area of the ports. They are all wrong together. For let us investigate the subject, and first of a perfect mathematically balanced slide-valve.

Fig. 7 is a section of a valve laid in middle position over the ports. Fig 8 is a plan of the same which shows it to be a parallellogram frame-work with communication ports A, through it. Let C be the cylinder face and S the steam chest cover, F F F are false ports $\frac{1}{4}''$ deep opposite the true ports. Let the steam be let on to this valve, it will act on the four outer sides pressing them equally. The exhaust pressure acts also equally on the four inner sides pressing them also equally. Let the valve now move from its middle position to the commencement of the stroke, the steam enters the port A and will press the valve from the cylinder face by a force equal to the area of the valve over the port, but it, at the same time, enters the false ports F pressing the valve to the cylinder with an equal and opposite force. Let it now move on to full port gradually decreasing the area of the valve exposed to the pressure in the port, but it as gradually decreases the area of the false port, and now, having got to full port, it returns gradually closing the port and increasing the area exposed to the steam. It has done the same over the false port and now the outer edge of the valve crosses the outer edge of the port, proclaiming the point of suppression and introducing the period of expansion. Commanding the pressure within the port to decrease, according to the law of gaseous expansion; but the communication port A permits of a free intercourse between the pressures in the true and false ports, until the inner edge of the valve crosses the inner edge of the bar, demanding the release of the steam from imprisonment in the cylinder. It rushes out through the port A with a velocity equal to the conditions of its own constitution, and enjoys the freedom of space outside the blast orifice, but it has, at the same instant, let free its companion in bondage in the false port. At the same time the opposite end of the valve closes the port to exhaust, and the steam, which was not released on the previous stroke, cannot now get out, but is compressed before the advancing piston, gradually raising the pressure in the port B, but the communication port *a*, ever faithful to its designer, again permits the pressures in the true and false ports to hold sweet communion with each other, and thus, it is seen, that the pressure cannot touch this valve on any one point without touching it on an equal and opposite point and practically at the same instant of time, and hence a perfectly mathematically balanced valve.

But, beautiful as the principle of this valve is, it contains the elements of self destruction in a large degree. It is a solid block manipulated by workmanship of the finest kind, and so fitted between two solid surfaces, such that it will move with ease between those surfaces, and at the same time be steam tight. This can be done to begin with conditionally. The author applied this to five locomotives on the London and Brighton and North London Railways, and its faults are: First, it is an inflexible block between two inflexible surfaces, and with the locomotive, whenever steam is shut off, the compressed air in the cylinder acts in front of the piston, and so powerful is it that it throws the driver forward on the fire-box and shakes every passenger in the train, and an engine will not run down a gradient of one in seventy at more than five miles per hour without steam on. Second, steam of high temperature cuts the surfaces rapidly, and soon permits a leak of steam, and thirdly, when it has been fitted and made steam tight the surfaces do touch each other, and no matter with how little force, they will run all right while steam is on, but shut off steam to run down a hill, and at any stroke the little touch generates heat, the heat expands the metal in the valve and does not expand the metal forming the walls of the steam chest. The valve sticks and the spindles are carried away, putting a period to the existence of this beautiful valve.

This is not therefore the valve best suited to practice, but one that will give and take to the inequalities and irregularities of the practice; for which purpose we introduce to your notice the valve of which Fig. 9 is a section and Fig. 10 a plan. Fig. 11 is also a half-section and at right angles to Fig. 9. Where V is the valve which is built up cylindrically to receive a ring D which displaces the required amount of steam from the back of the valve, so that at the mean position the negative forces shall be equal. R is a packing ring to make a steam tight joint between V and D. F is the door or cover of the steam chest, S is a three ounce spring to hold D against

F, and V against the cylinder face, and H H are two small holes to allow the exhaust pressure of steam acting in the cavity of valve to come through the back of the valve.

Steam being admitted to this valve, it will act under the head of D pressing it hard against F, but it also acts between the head and F with an equal force, no matter how fine the surfaces are scraped, and as the areas above and below are equal, it is held in equilibrium of the forces. The exhaust pressures acting in cavity C pass freely through H H, and acting equally on both sides of D internally, hold it also in balance. In movement also the forces on the valve balance each other.

Within certain limits of the balance of the valve, determined by a series of experiments by the author, extending over a period of four years (and numbering altogether upwards of eleven thousand) it has been determined by the author that, practically, the forces are balanced over the spaces *a a* and *c*, because the spaces are equal and opposite, but the spaces *b b* and *c* are not balanced because they have the full boiler pressure of 120 pounds on them as positive force, while there is but the exhaust pressure of 3 pounds below, it is therefore an unbalanced positive force. Nor are the spaces *b′ b′* and *c* balanced either, for while they have the exhaust pressure above, they are exposed to the full initial pressure below. Moreover the spaces are neither equal nor opposite, but our task is to balance them. Fig. 12 is a section of Buchanan's valve, as given to the author by that gentleman, in order that the author's valve may be applied in its stead. It is required to find the diameter of displacement ring such that the forces may balance each other.

Draw the centre lines and let their intersection C be the centre of the valve, of which Fig. 13 is a plan. On C, as a centre describe any circle D E F, draw the line *n n* leaving the spaces *n′ n′* equal to the space *m*. We have now got a triangle to calculate which is easy. Bisect the base of the triangle *n o* and from it draw a line to the opposite angle *n*, one-third that distance is the centre of action of that space, X and the base multiplied by half the perpendicular height gives us the area, and the area multiplied by the distance of its centre of action from the centre of the valve gives the moment of the force.

Similarly for P draw the line *n y*, leaving the space inside the line of displacement equal to that outside, draw the diagonals and the point of intersection in the centre of action of the rectangular space P and one side multiplied by the other and multiplied by the distance of its centre of action from the centre of the valve, gives the moment of the force P. The moment of the two forces N and P being equal, the valve will be practically balanced, thus: 3·7 × 2·85 × 4 = 42·18 = moment of negative force. 2·25 × 2·85 × 6·5 = 42·33 = moment of positive force, and a valve so proportioned and constructed (Fig. 9) will move as easy with steam of any pressure on, as off.

In proof of the truth of this theory the author purposes to lay before you a few of his experiments bearing directly on the subject, from which you will see the mode of reasoning he adopted in arriving at these conclusions.

Having discovered the law that to hold any two surfaces of metal together, moving in molecular contact against a heated fluid under pressure, it required a force equal to the area of the surface in contact multiplied by the pressure against which the body moves. The following experiments with the displacement ring were to prove that law. Fig 14 is a plain ring D, the section of which is three-quarters of an inch thick. Conceive it to be parallel up to the steam chest cover F, the bearing surface against E is ¾″ and a strong spring S, of any force, is put under it to hold it tight against F. Steam of low pressure is let in on the valve, 3 pounds to the square inch, the valve is in motion and all is tight, the pressure rises to 10, 15, 20, 25, and at 26 pounds a blow takes place; the higher the pressure, the greater the blow. The ring is taken out and a quarter of an inch recessed out of the head, as shown at E, leaving only a half-inch bearing against F, when steam is again let on and at 26 pounds all is tight, so at 30, 35, and at 39 a blow was the result; the higher the pressure the greater the blow. The ring was again taken out and another quarter of an inch recessed out of its head, as shown at E′, leaving only a quarter of an inch now bearing against F. When steam was again let on and at 26 and 39 pounds all was tight, and at 78 pounds a blow again took place, the higher the pressure the greater the blow. It was now taken out and the spring weighted to its working deflection, when it showed a difference of 1 pound 14 ounces only per square inch, from the area of the surface in contact multiplied by the pressure at the point of blow.

It was next applied to a Locomotive on the North London Railway by Mr. William Adams, and at the same time to one on the Great Eastern Railway by Mr. Sinclair, in the form of Fig. 15. The head of the ring bearing against the door is half an inch wide, and the body of the ring five-eighths thick, the head of the ring is recessed a sixteenth of an inch. Two strong springs were put under it to wear the sixteenth away, and so bring the body of the ring up on to the door. It did so, and a blow was the result in both cases, the extra surfaces against the door being $1\frac{1}{2}$ square feet. It was taken out, and as it did not wear equally all around, and a ring with a head, as shown in Fig 16, put in. In four months we got a blow there also, it was taken out and the top surface measured three thirty-seconds of an inch more than the bottom. It was recessed, as shown in Fig. 17, and will have been four years at work come the first day of August next.

The question will be asked how do we account for this variation in the areas of the top and bottom surfaces of the displacement ring.

Fig. 18 is a plan of the head of the ring, and C the centre of formation. Square the outer and inner radii of the ring, add the sums together, divide by two and extract the square root of the remainder, the quotient will give the radius of the centre of action of the head of ring, and the centre of action of the semi-circle bounded by the outer and inner radii will be ·707 of the radius of the centre of action of the area, thus,

Let C be the centre of formation and C' C'' the outer and inner radii, and C''' the centre of action of area, and C'''' the centre of action of the semi-circle.

With motion in the direction of arrow A'' it is evident that the semi-circle A is moving against the full initial pressure of the boiler 120 pounds, while the semi-circle A' is moving against the exhaust pressure of three pounds it is evident that the centre C cannot be the common centre of action of the two semi-circles, but in some point towards the greater of the two pressures.

Let T equal the temperature of 120 pounds, measured from the absolute zero of temperature, equal 794° Fahr. and T' equal the temperature of 3 pounds, also measure from the absolute zero equal to 713° and let $C\,C''''$ be 3·75 inches, then will

$$\frac{794 \times 3{\cdot}75 - 713 \times 3{\cdot}75}{1507} = {\cdot}204$$ of an inch in the direction of the larger temperature, giving the proportions of 7 to 8 as the propor-

tion of bottom to top surface of head of displacement ring, and this rule will give the correct proportion to all variation of diameters and pressures.

This brings us now to the application of the author's valve to the marine engine, for which purpose we select the Franklin, the Flag ship of the United States Navy, as applied by Chief Engineer W. W. W. Wood, of the N. Y. Navy Yard.

Fig. 19 is a section which shows it a double ported valve, Fig. 20 is a half plan. Then as before describe any circle B, D, F, set off the spaces N N′ N″ N‴ as unbalanced negative areas and find their centres of action, then will each area multiplied by the distance of its centre of action from the edge F F of the valve, give the moment of its respective force, and their sums added will give the total negative force.

Similarly for the positive force set off the spaces P, P′, P″, P‴, and find their centres of action. Their areas multiplied by the distance with which their centres act from F F gives the moment of their forces, their sums added will give the positive force, thus,

$$3{\cdot}1 \times 1{\cdot}1 \times {\cdot}5 = 1{\cdot}7$$

$$8{\cdot}7 \times 1{\cdot}4 \times 4{\cdot}5 = 52{\cdot}19$$

$$10{\cdot} \times 3{\cdot}2 \times 18{\cdot}3 = 585{\cdot}64$$

$$5{\cdot}7 \times 2{\cdot}5 \times 22{\cdot}6 = 287{\cdot}$$

$1{\cdot}7 + 5{\cdot}2 + 58{\cdot}6 + 287 = 927$ = moment of negative force.

$$10{\cdot} \times 2{\cdot}5 \times 2{\cdot}25 = 56$$

$$6{\cdot}3 \times 2{\cdot}4 \times 6{\cdot}1 = 92$$

$$8{\cdot}9 \times 4{\cdot}7 \times 11{\cdot}9 = 497$$

$$8{\cdot}3 \times 1{\cdot}7 \times 20{\cdot} = 282$$

$56 + 92 + 497{\cdot} + 282 = 927$ equal moment of positive force. The moments being equal the balance is complete.

It will be seen that this valve is laid at the commencement of the stroke. The effort of the negative forces is to turn the valve off the edge F F as a fulcrum, and they would do it, too, were the moment of their sums greater than the moment of the sum of the positive forces and the valve would leave the cylinder face.

We have next to prove that the pressure on the back of the valve is not equal to the area of the ports. This being the prevailing idea of engineers.

Fig. 21 is Buchanan's valve. The elements of the valve, lap, lead and travel are the same, and the ports are all the same, length and breadth. The only dimensions that are altered is the width of the inner bar on the cylinder face, in the former case. Fig 12 the bar is one inch. In the latter, Fig. 21, it is three inches. In Fig. 13, applying the author's rule, the area of displacement is 84·5 square inches. In Fig. 22 it is 154 square inches, which, with 120 pounds of steam, shows a difference of 8·400 pounds on each valve. The same rule being applied in both cases, the prevailing idea is therefore as false as the bottom of a tailor's thimble.

The next rule is that which makes the weight on the back of the valve equal to the whole area of the valve. Such an assertion requires only to be made in order that it may be condemned, for it ignores the existence of any negative force at all.

And, lastly, we have those who say that it is equal to the whole area of the valve, minus the two admission ports.

Fig. 23 shows the valve upon which the author made his experiments, beginning by displacing the whole of the area of valve, minus the area of the two admission ports, represented by the outer diameter of ring, the result was that the valve left the cylinder face, and a blow of steam through the ports was the result, rings of smaller and smaller diameters were then applied, decreasing by $\frac{1}{8}$ or $\frac{1}{16}$ inch at a time. The valve always leaving the cylinder face which showed plainly that the negative force always prevailed over the positive, until, at last, one was fitted and the valve kept the cylinder face. It was taken out and measured, and the circle A, B, C, represents the displacement, from which the rule was made.

Experiments were also made to determine what amount of load was necessary to produce friction, and whether or not an uniform increase of load would be met by an uniform increase in the co-efficient of friction. It was not so, for friction was only produced by a load of seven per cent. with superheated steam 560° temperature while with saturated steam of 10 pounds pressure it required 34 per cent. to produce friction, and it is not uniform, but sudden.

These experiments leave no doubt whatever of the existence o a film adhering to the surface of the metals, and this film ha been the stumbling block and rock of offence which has deceive all engineers; for, give the relation of surface to pressure, an almost any engineer has enough mechanical skill to build the structure. The valve, in moving against it, slides over it, and so lon as its temperature is maintained, it possesses all the energy of th surrounding steam. It is an elastic fluid possessed of energy. I will therefore perform a given amount of work equal to its equivalent of heat, which it does in supporting the load, as the valve moves over it, and when its heat is destroyed friction sets in.

The fulcrum of both forces is continually changing when the valve is in motion. The positive traversing about 1½ inches on either side of the centre of the valve, while the negative traverses the whole length of the valve during one revolution, and thus an incessant war is set up between area on the one hand, and leverage on the other. At one time the greater area of negative force prevails and says to the lesser area of positive force, "I will push the valve from the cylinder face;" when the positive force replies "I will exercise my prerogative of leverage and will not allow you." The area says "I am the biggest and you must obey." The leverage says "I am the more powerful and will be master," and thus by the war of area on the one hand and leverage on the other, the valve is incessantly being thrown from the cylinder face, and as incessantly being thrown to it, and thus it has no peace. The molecules of the valve face can never embrace those of the cylinder face in the bonds of friction, but by it the valve is made to float on the fluid skin of the surfaces, and hence the ease with which it is moved.

London, December 10th, 1869.

Glasgow Harbor Extension.—M. J. F. Bateman, consulting engineer to the Clyde Trust, and Mr. James Deans, the lately appointed resident engineer, have given a large amount of attention to this subject, it being the intention of the Trustees to go to Parliament in the ensuing session for the necessary powers to enable them to proceed with such harbor extensions as the circumstances of the case, present and prospective, demand. Taking in consideration the varying increase of quayage from time to time, the engineers determined to calculate upon 200 yards per annum as the required rate of increase for the next ten years. "At the same progressive rate of increase in the trade" they proceed, "the additional quayage required on the average of the following ten years will be about 300 lineal yards per annum, showing a mean of 250 yards for the next twenty years.—*Engineering.*

Mineralogy of Yosemite Valley.—Garnets, sphene molybdinite, hornblende, and other interesting materials, are reported by Mr. J. H. Casewell to be plentiful in the granite of Yosemite Valley.

IMPROVED PROJECTILES FOR RIFLED CANNON.

By Lieut. John G. Butler, Ordinance Department, U. S. A.

The close attention which Rifled Ordnance is now receiving from the best military talent of this, and especially of foreign nations, will, perhaps, fully justify the following description of what has been done in this country to overcome the hitherto grave objections to rifled guns and elongated projectiles.

Without describing the multitudinous devices for securing the rotation of rifle projectiles, more popularly described as taking the groove, it will suffice to state that nearly all are comprised under three general systems, namely, the compressing, the expanding, and the centering. The centering system may embody the compressing and expanding systems to any required degree.

Holly, in his book on ordnance and armor, says:

"The principal defects of the compressing systems are:—

"1. It unduly strains the gun by suddenly stopping all windage, by fouling, and by forcing the shot into a bore of smaller diameter.

"2. It reduces the velocity of the shot by compressing and fouling.

"3. The increasing twist is impracticable from the great length of soft metal coating.

"4. The soft coated projectile is liable to injury in handling and in store.

"5. The windage is entirely stopped, thus increasing strain, possibly diminishing accuracy and rendering the use of time fuges uncertain.

"6. Soft coatings are liable to be so much loosened by the heat of molten metal, that shell could not be charged with it.

"7. Compressed shot must be fired from breech-loading guns.

"The advantage of the compressing system over the expanding —but not over the coating system—is, that it holds both ends of the shot in the centre of the box during its passage.

"The chief defects of the expanding system (hitherto almost exclusively used in the United States) are:—

"1. The centre of gravity is almost, necessarily, behind the centre of figure.

"2. The bearing of the projectile is behind the centre of gravity, both of which features tend to cause inaccuracy.

"3. The sudden stoppage of windage unduly strains the gun.

"4. Fouling, and the violent wedging out of the soft metal to fill the grooves, are evident sources of strain.

"5. The shot is liable to injury, and the disadvantages in firing time shells are the same as in the case of compressed projectiles."

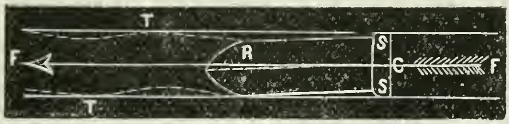
To the above, in both the compressing and expanding systems, should be added the stripping of the soft material and the consequent failure of the projectile to take the groove, while pre-eminently to the expanding class of projectiles belongs the defect of balloting, with all its attendant evils.

Holly further says:—"The centering system, as practiced by Whitworth, Lancaster, and others, who use grooves that the shot can wedge in, strains the gun unduly and decreases the velocity of the projectile."

The balloting or rebounding of a projectile within the bore of a gun is, next to absolute wedging, an undoubted source of great strain to the gun, and a primary cause of bursting.

To illustrate the cause of balloting, its injurious tendency, and finally the manner in which it may be overcome, reference is made to the following diagram.

Fig. 1.



Which represents an expanding sabot projectile, with exaggerated windage.

The first effort of the discharge is to expand the sabot S S, into the groove of the gun, which expansion we will assume to be uniform. The rear of the projectile is thus centered, *i. e.* the centre of figure of the base of the shot is placed in the axis of the bore F F′, but F F′ is also the resultant of all the forces of discharge, and while the *rear* of the shot is centered, the *front* portion is not so, but rests upon the bottom of the bore R. Now the line of direction F F′ of the discharge, passing through C, and above the centre of gravity of the shot, the point R, of the latter, is forced upon the bottom of the bore at T. From this point it rebounds until the point R′ strikes he bore at T. From this point the projectile is thrown off with ncreased violence against the point T″, and so on throughout the bore, each blow is more powerful than the preceding, owing to the increasing velocity of the shot and the impetus gained from its previous contact with the walls of the gun, and it is further obvious that the quicker the motion the more violent is the balloting.

For a more homely illustration of the above, who has not tried to raise a window with one hand? The hand is not fairly in the middle of the sash, the centre of gravity moreover is above, *i. e.* in *front* of the hand—the sash is raised easily at first, and then begins to "wabble," its vibrations increase in violence as we push, until finally it almost comes to a dead lock, and without reflecting much about the matter we apply *both* hands, unconsciously *centre* the window and up it goes without further difficulty.

The bad effect of balloting is not limited to injury of the gun. The last rebound of the projectile, intensified by the last effort of the discharge, occurs as the projectile is leaving the gun; the front end of the shot no longer incurs resistance from the walls of the bore, hence its great tendency to turn end over end.

Little doubt now remains that the bursting of many of our large guns, and particularly the short life of our heavy rifles, is due to balloting and wedging. General Dyer, in his last report, states "that most enormous pressures, and yet diminished velocities, have been obtained with charges calculated for, and ordinarily giving, greater velocity and one-third the strain."

The general problem in gunnery seems now to be *to secure uniformity of velocity, pressure and range for the same charge.* This it is proposed to accomplish, and in actual experiment has been accomplished, by a successful adaptation of a combined centering and rotating principle to the *front* as well as to the *rear* of the projectile whereby we are enabled to increase their length, and to diminish when desirable, the thickness of their walls; to replace the solid shot with a battering shell of equal or superior weight and penetrative power, with a destructive force still in reserve; to increase the general size and weight and widen the field of application o rifle projectiles; and finally to obtain great uniformity in the range velocity and pressure. For the projectile leaving the gun with mechanical fit, front, as well as rear, balloting, always so destructive, is effectually prevented. The co-efficient of friction become as invariable as in a machine, pressure and velocity will alway bear their due relation, and the only cause for variation in eithe will be due to the irregularity of the charge itself, in quantity o quality.

This system is illustrated upon the adjoining plate. Fig. 1 represents a six or eight inch shell of ordinary length. Here is seen a brass stud *a*, *b*, *c*, *d*, *e*, cast into the body of the shot and thoroughly secured by the under-cuts at *d* and at *g* and *g′* in the side figure. The other studs being secured in like manner, and there being a stud for each gun, the action is clear; unlike the sabot, which from being too soft is immediately expanded by the gas, but is stripped by the groove, or the harder ring which is insufficiently expanded in the first place; the gas enters under the studs at E, and with ease expands or lifts them well into the grooves.

The studs are made so low as to allow the projectile to be loaded with the greatest facility, yet stripping is rendered impossible, for the first effort of the discharge is to lift the studs into the grooves, securing thereby the full benefit of the same, and keeping the contact absolutely perfect so long as the projectile remains in the gun; as long as attrition of the studs continues they are kept in fresh contact with the bottoms of the grooves by the continued action of the gases. The studs thus retaining a maximum distinction the shot is well lifted, the bearing in each groove full and perfect, and the rotation of the projectile fully assured. In order, however, to secure a perfect flight, it is necessary to effectually prevent balloting and therefore to centre the front as well as the rear of the projectile. To this end the gas which escapes between the studs in the rear, is utilized in the expansion of a metallic ring fixed upon the front of the shot, in a manner readily understood by reference to Fig. 1. The projectile is reduced in calibre between the limits K and K′ an annular shot is either rough cast, or turned and drilled, into which is cast a metallic ring flush with the superior surface of the projectile, and overlaping the tapered surface of the same to any desired extent, as *o m*. It will be here seen that the gas escaping through windage, forces itself under the ring at "M," and after the manner of the ordinary sabot, expands it against the bands and into the grooves of the

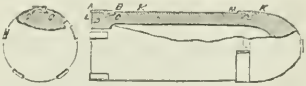


Fig. 2.

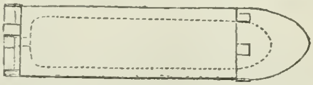


Fig. 3.

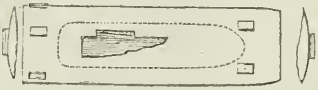


Fig. 4.

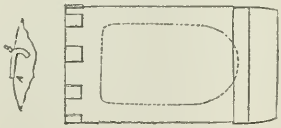


Fig. 5.

gun. The main duty of the first centering band being to centre the projectile. It is only essential that it should press hard enough upon the bands for this purpose, though experience proves that if of brass it takes a fair impression of the grooves, and therefore assists, to a certain extent, the studs in their duty of rotating the shot.

This assistance in long projectiles with their walls is necessary to prevent the latter from being broken, *i. e.* twisted asunder, and in any event is highly desirable in heavy shot. Fig. 2 shows an arrangement of lifting or expanding studs upon the front as well as the rear of a heavy projectile, whereby the projectile is not only centered front as well as rear, but is also rotated from both points. If centering alone is desired the front studs may be flush with the projectile, and arranged so as to be expanded against the bands of the gun, and when the number of grooves is even, the front and rear studs may alternate instead of being arranged in pairs. The studs may also be connected by a band [forming part of the same casting] which can be so arranged as to close windage.

By the adoption of this centering system we will be enabled to use very long projectiles with solid heads, after the manner of the Whitworth, and none will probably dispute the fact that for the same strain upon the gun a larger and heavier projectile can be used than Whitworth dare attempt.

The solid headed projectile is admirably adapted to size and battering purposes. The head is strong, unweakened by fuge hole and tapping, and may possess any desired form for penetration, unwilling, however, to trust to the impact of the projectile to generate heat enough for the explosion of the charge—a system of interior or rear fuge plugs is recommended, whereby the explosion of the shell at the proper instant is secured beyond a doubt. A number of these fuges have been devised and submitted but it is not in the province of this article to describe them.

In Figure 4 the bases of the studs are entirely embedded in the shot, each stud is split half-way through its length. The solid parts of the studs perform their duty by rotating the projectiles, assisted by the divided portion, which part, also, by expanding freely into the grooves, centre the shot front and rear. In this case the gun, having an even number of grooves, the front and rear studs alternate.

Still another form remains to be represented in Figure 5, which is a 15 inch or other projectile of large calibre. In this case, instead of brass, unwrought iron studs may be swedged into the cavities left for that purpose in the projectile. The gas enters along the line *a b*, and turns the stud on to the right, a full bearing surface upon the deep side of each groove is thus obtained and the projectile centered as before.

It is believed that rifle projectiles will yet be fired from guns of 15-inch calibre. The object in this case is not so much to secure greater penetration—for we cannot afford, perhaps, in guns of such large calibre, to *greatly* excel the weight of the round shot—but

1. To secure greater accuracy.
2. To obtain increased bursting charges.
3. To generate explosion at the right instant by means of interior percussion fuges, instead of trusting to time fuges as must be done with round shell.
4. To insure penetration of armor even when struck at extreme angles.
5. To obtain uniformity of pressure (strain) velocity and range for uniform charges of powder, which can only be done by giving the projectile bearings, front and rear, upon which it can slide out the piece without jar.
6. As much increase of penetration as is due to increased weight and better maintained if not equal velocity.

While fully admitting the tremendous power of our large smooth-bore guns, the time is assuredly approaching when rifled guns, of like calibre, will be found to possess at least equal endurance, much more general in their application and have superior powers of distinction.

Ferry Steamship for the Channel Passenger Traffic.—At the ordinary meeting of the Institution of Engineers in Scotland, verbal communication of great interest was made by Mr. Walter Montgomerie Neilson regarding a suggested form of ferry steamship for the channel passenger traffic. He suggested a vessel of 350 feet long by 75 feet broad, and having only 4½ feet draught of water. She should be worked by a pair of paddles near each end, and to give steadiness, or in other words, prevent rolling, Mr. Neilson would have a keel of 20 feet in breadth, movable, and that could be raised by means of a pair of donkey engines when the vessel approached the harbor at either end of her voyage.

EXPERIMENTS UPON A CENTRAL DISCHARGE WATER-WHEEL.

Manufactured by the Swain Turbine Company, at North Chelmsford, Mass.
Made at Lowell, Mass.

By Hiram F. Mills, C. E.

The Central Discharge Iron Wheel, known as the Swain Wheel, has been in use in various parts of New England for several years, and has been known as a substantially built wheel, giving very general satisfaction wherever used, and quietly gaining, upon its merits, a reputation for good construction and efficiency.

In the winter of 1868–9, the company owning the patent rights was reorganized upon a broader basis, and retaining as their superintendent Mr. A. M. Swain, the inventor and former manufacturer, concluded to enlarge their capacity for production, and submit their wheel to the most rigid tests of experiment, with a view to their introduction into the large manufacturing establishments at Lowell, Lawrence, and other places where great economy in the use of water is required.

They accordingly constructed a flume, a pit and a measuring weir at one of the wasteways of the Wamesit Power Co.'s Canal, in Lowell, and put in a 42-inch wheel, which they had recently made for The Forge Village Horse Nail Company, of Forge Village, Mass.

Early in June, 1869, after the wheel was in, and a weighing apparatus, invented by Mr. James Emerson, of Lowell, and known as Emerson's Dynamometer, was attached, the writer was applied to, to make experiments and determine the efficiency of the wheel.

Upon examining the apparatus for weighing, it was found to be very ingeniously designed, but the results being indicated by the height to which a pendulum would vibrate, could not be depended upon with sufficient accuracy, owing to the slight oscillation upon either side of the mean point when the wheel was heavily loaded; and it being necessary to test the apparatus at every point at which it was to be used by some known standard, it was concluded to dispense with its indications entirely, reserving in use only the very ingenious method which Mr. Emerson had devised for keepthe friction-wheel and the friction-band cool and of an even temperature, by the circulation through each of a stream of cold water, and the application of oil to the frictional surface by means of cups attached to the band.

Reserving in use this part of the apparatus and attaching a radial projection to the band and connecting this by a link having knife-edge bearings, to the vertical arm of a bent lever, from the horizontal arm of which a scale pan was hung, and attaching near the bearing of the scale beam, a horizontal arm in the same line but in the opposite direction, at the extremity of which was attached the piston rod of an hydraulic regulator; we had a friction brake of simple form and capable of very delicate adjustment.

The flume and pit were tight, and the bottom of the latter being from one to three feet above the ground, with this space open to view, it was seen to be impossible for any water to leave the wheel except that which passed the measuring weir.

The measuring weir was carefully made, following, in all respects, the directions given by Mr. Francis in his "Lowell Hydraulic Experiments," in order that his formula might apply with accuracy.

The relation of parts will be evident from an inspection of the accompanying plates.

Plate I. represents the wheel in place, with the flume, forebay, pit, measuring weir and weighing apparatus in plan and elevation, with a part of the northerly side of the pit removed, the better to show the case containing the wheel.

Plate II. represents a vertical section through the centre of the wheel and curb, and a plan of one-quarter of the buckets and guides, and a development of a portion of the outer surface of the wheel.

Plate III. represents upon a larger scale, in plan and elevation, the weighing apparatus used in these experiments.

In Plates I. and II. the letters indicate corresponding parts.

A, the flume, 6 feet wide and 6 feet deep, leading the water from the Wamesit Power Co.'s Canal.

B, the forebay, 6 feet square and 19 feet deep, from the side of which water is conveyed to the wheel.

C, the wheel pit, upon the floor of which rest the cast iron sup. ports of the wheel and its case. The pit is 14 feet wide and 20 feet 6 inches long, with sides 5 feet high.

The cast iron supply pipe and the quarter turn, D, are 4·98 feet in diameter inside, and the radius of curvature of the central line of the latter is 3·75 feet. The former is 1·45 feet in length, and is firmly bolted to the side of the forebay.

The quarter turn is bolted to the supply pipe, and is supported by the cast iron case, which enlarges to have an internal diameter of 6·98 feet. This case extends to a short distance below the bottom of the wheel, and is supported by six hollow cast iron columns 1·5 feet long, 0·8 feet wide radially, and 0·3 feet wide in the other direction, and presenting acute angles in the direction of the current.

The columns also support the cylindrical disk E, Plate II., which surrounds the lower half of the wheel, and upon the outside of which the regulating gate slides; and by means of three irregularly shaped supports, one of which is represented at F, they sustain the chamber G, into which the guides rise when the gate is closed, also the disk H which covers the wheel, the lower shaft coupling and the step; and the shaft-pipe I which extends from the top of the disk through the upper part of the quarter turn.

The disk K, cast with the six supports of the case, sustains the step of the wheel L and the main shaft M.

The step L, of white oak, is a cylinder 7 inches in diameter terminated at top and bottom by cones, and having an extreme length of 8 inches.

It is free to move with the shaft coupling, or the latter may move upon its upper surface.

The step is always submerged, and to maintain its surfaces in as good a condition of lubrication as possible, several vertical holes were bored through it and filled with a fine quality of plumbago.

By means of the set screws N, the wheel may be adjusted to the proper height. These screws are reached through hand holes in the curved disk which connects the wheel with the shaft.

The regulating gate, O O, is represented as fully open. It consists of a cylinder of cast iron $7\frac{1}{2}$ inches long, 3·51 feet in diameter inside, having at the bottom a narrow flange, against which a ring of leather packing is held by means of bolts and a cast iron ring, by which leakage under its lower edge is prevented, and at the top, cast with it, and making an angle of about 80°, is a broad flange extending outward $7\frac{1}{4}$ inches, with an edge turning downwards.

This flange serves as the lower disk limiting the stream of water entering the wheel, and into it, projecting vertically from its upper surface, the guides P P are cast.

There are 24 guides, 21 of which are of straight plates of wrought iron $\frac{3}{16}$ inch thick, and $10\frac{7}{8}$ inches long, having each end sharpened to a thickness of $\frac{1}{32}$ of an inch, with a bevel $\frac{1}{2}$ inch long. The mean distance of their inner edges from the centre of the shaft is 1·835 feet, and they are distant radially one inch from the outer edge of the buckets. Their direction makes an angle of 22°, with the tangent through their inner edges.

The remaining three guides are of cast iron of the form represented in plan at O in Plate II., Fig. 2.

Through these guides pass the three wrought iron rods by which the gate is raised and lowered. Two of these are represented at R. They extend from the under-side of the gate flange through stuffing boxes in the upper part of the quarter turn, and terminate in racks S S, into which work the pinions T T which are driven through the worm U by the crank V.

Outside of the three cast iron guides are the three supports F previously mentioned.

When the gate is raised, by which movement it is closed, all of the guides rise through slots in the upper disk limiting the stream approaching the wheel, which is similar in form to the lower disk already described, and are enclosed in the guide chamber G, by which arrangement the section of the stream passing between the guides is decreased in height in proportion to the closing of the gate.

The wheel W having an extreme diameter of 42 inches, and an extreme height of $15\frac{7}{8}$ inches, has 25 buckets of wrought iron $\frac{1}{8}$ of an inch in thickness, which are formed in a die and are cast into the upper disk *a a*, which forms the crown of the wheel, and into the band *b b*, which surrounds the lower part of the buckets for a height of 8·42 inches, leaving between the top of this ring and the under side of the crown a space 5·35 inches high, through which the water enters the wheel.

The horizontal projection of the top of the buckets, and of the upper part of them for a depth of 5 inches is shown by the heavy lines in Fig. 2, Plate II., and Fig. 3 represents the development of a portion of the cylindrical surface containing the outer edges of the buckets.

The diameter of the cylinder which would contain the inner edges of the buckets for a depth of 5 inches would be 2·092 feet. Below this portion the surface which would contain the inner edges of the buckets is a surface of revolution whose element is a quadrant having a radius of 8·4 inches.

The under side of the crown of the wheel is horizontal through a radial distance of 4 inches from the outside, for the remaining distance it forms part of a surface of revolution whose elements have a radius of 11 inches, which surface continues downward and towards the shaft, and forms part of the cylindrical socket *c c*, which surrounds the step and its supports.

Upon removal from the pit, the wheel was found to be of ordinary finish, similar in all respects to other wheels which I have seen manufactured by this company.

The castings were well cleaned, but the ordinary roughnesses of good castings were not removed.

The surfaces were coated with red paint.

The following dimensions were measured after the wheel was removed from the pit.

Vertical distance from the under side of the crown to the lower edge of the buckets	1·148 feet.
Vertical distance from under side of crown to top of band	0·446 feet.
Mean shortest distance of the inner edge of one bucket from the adjacent bucket at 1 inch below the crown	0·065 feet.
Ditto, ditto at 5 inches below the crown	0·080 "
Ditto, ditto at 1 inch from the outside at the bottom...	0·135 "
Mean shortest distance from the inner edge of one guide to the adjacent guide	0·214 "
Mean shortest distance from the outer edge of one guide to the adjacent guide	0·332 "
Mean area of outlets of wheel	18·97 sq. ins.
Total area of outlets of wheel	3·29 sq. ft.

Description of Apparatus used in the Experiments.

The weighing apparatus is shown in place in Plate I., but it will be better understood by reference to Plate III., where it is represented upon a larger scale in plan and elevation.

The friction pulley, A A, is of cast iron, having a groove cast in its outer edge, and a tire of steel shrunk on, making a passage (seen in section at E) for water, which is introduced from the tin vessel B, through the rubber pipe C, and after passing to the right around the wheel, is discharged through the iron pipe D, into a tin vessel which surrounds the shaft as seen at X, in Plate I., from which a rubber pipe conveys it away beyond the pit. The steel face upon which the friction band slides is 50·4 inches in diameter, and $3\frac{1}{4}$ inches wide. This surface would be much too small to control the power of this wheel were it not for the admirable arrangement of water passages by which, by the constant flowing of cold water from the flume, the surfaces are kept cool and of an even temperature.

Fig 1.

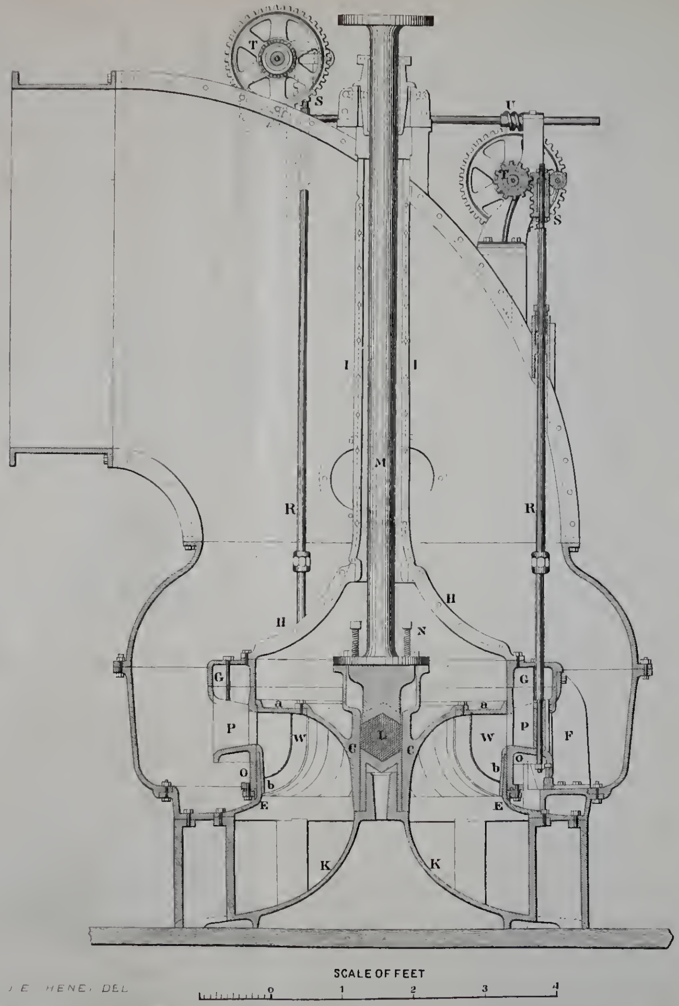


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Fig 2.

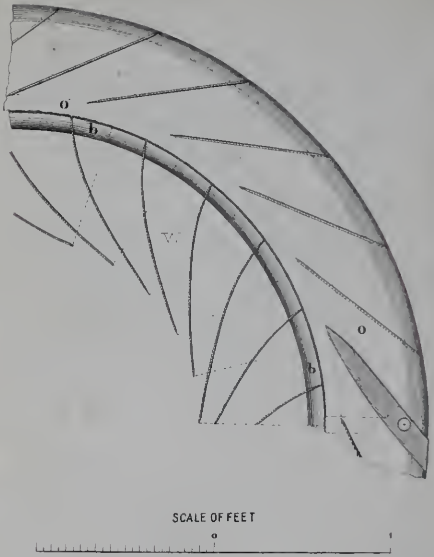
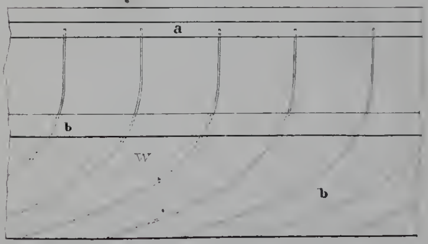


Fig 3.



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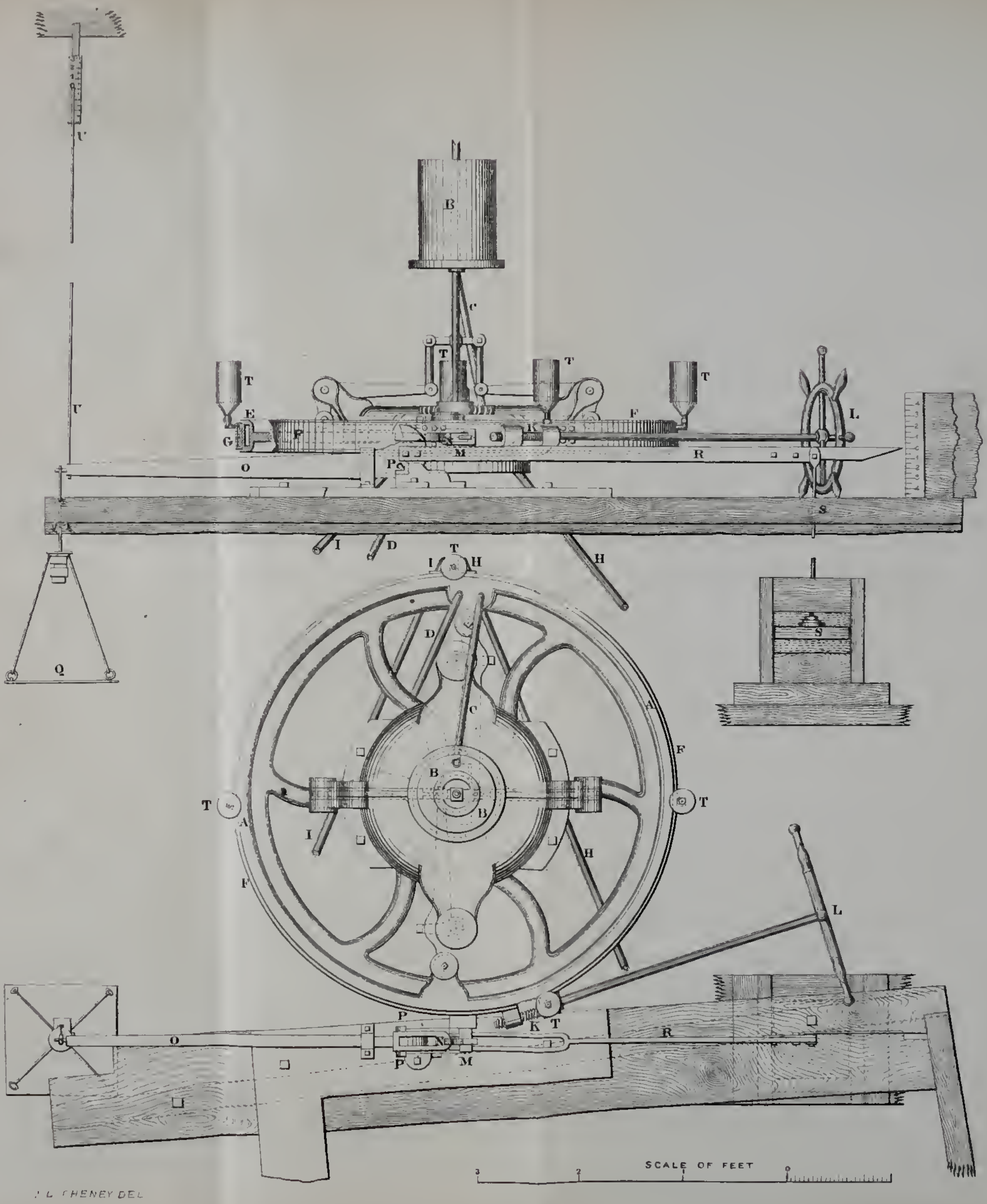
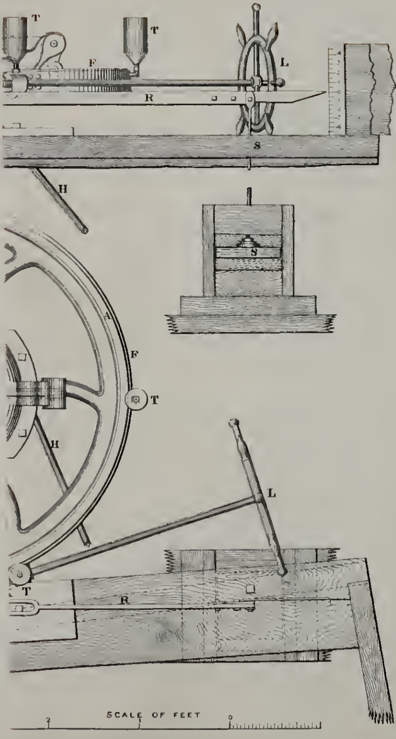
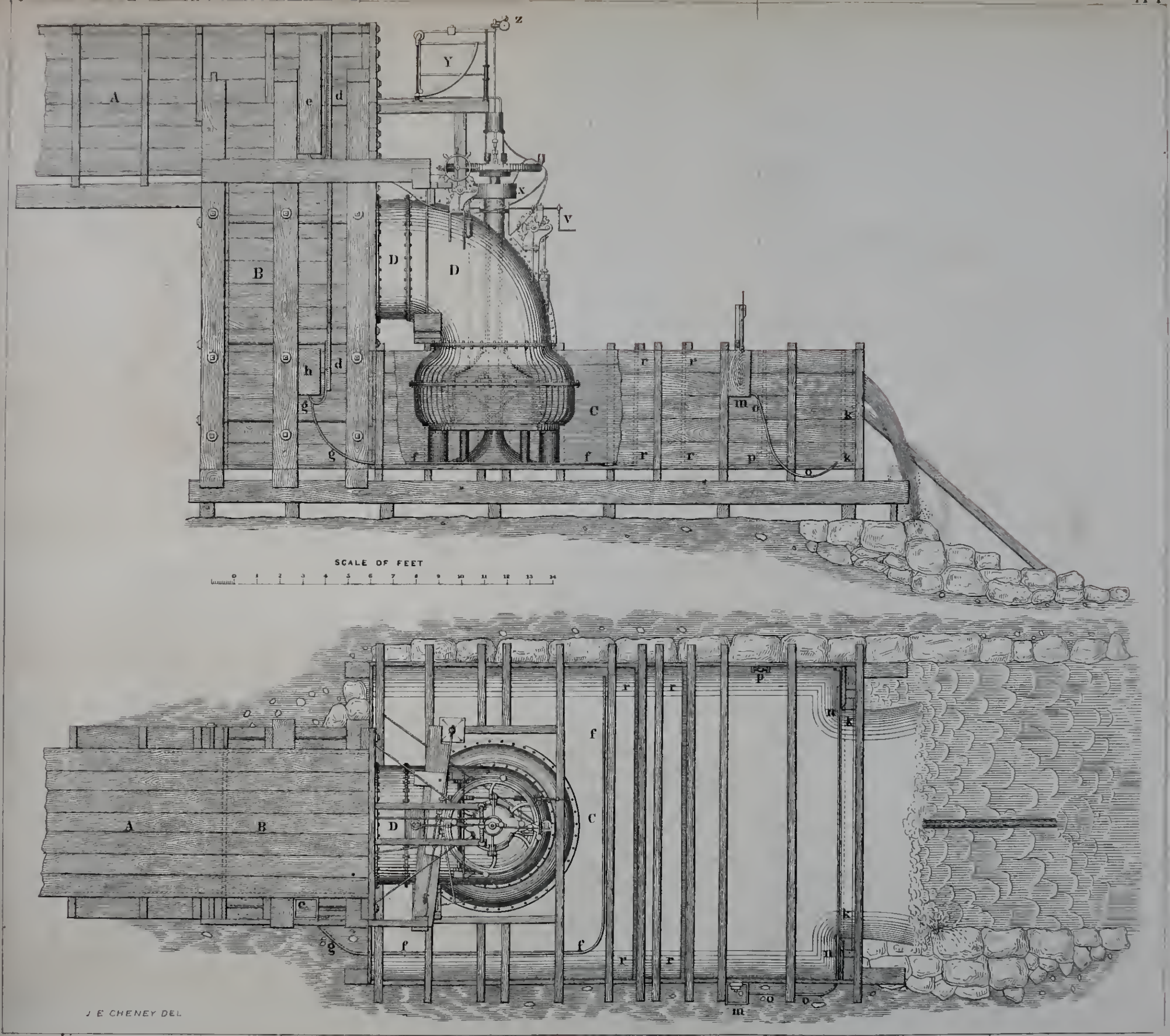


J. L. CHENEY DEL.

Lith. Jas. W. Queen Phila.

Pl. III





J. E. CHENEY DEL.

Lith. Jas M. Gungan Philada

In addition to the passages already described, the friction band, F F, consists of an inner band of wrought iron having a flange projecting outward at the upper and lower edges, and a projection along its middle line, upon the outside of which is soldered and riveted a copper band, by which are formed two passages, represented in section at G, which come together near the ends of the band.

Into the upper of these passages, nearly in the middle of the length of the band, the rubber pipe H H conveys water from the forebay, which, after passing to the ends of the band, returns by the lower passage, and passes out, and is conveyed beyond the pit by the rubber pipe I I.

By this arrangement it was often found that after running steadily, when heavily loaded, for an hour, the band felt barely warm to the hand.

The friction band was drawn around the pulley, covering the entire circumference except about two inches between the ends; and the amount of friction was regulated by the screen K, and hand-wheel L, which was suspended from the roof by a wire, so that it was necessary to keep the hands upon it only when a change was required.

From the casting at one end of the band, which formed the nut into which the screw worked, was the projection M, fitted to receive one of the knife edge bearings of the link N, the other bearing of which fitted one arm of the bent lever scale beam O. Directly under this bearing and exactly 4 inches from it, was the knife edge bearing P of the scale beam; and from this point horizontally along the scale beam 40 inches, was the bearing for the knife edge by which the scale pan Q was suspended. These knife edges and bearings were all of hardened steel and preserved their lines of contact in good condition throughout the experiments.

Bolted to the scale beam near its bearing and extending in the opposite direction was the arm R, to the extremity of which was attached the piston rod of the hydraulic regulator S.

The frictional surface of the pulley was lubricated by means of the four oil cups T T, the tube from which extended through the band. Linseed oil was found to allow a more steady motion with heavy loads than any other lubricator used.

The light rod U, moving with the end of the scale beam over the graduations of the scale placed so as to be visible to the assistant regulating the friction by the hand-wheel L, indicated when the scale beam was level and how much it deviated therefrom at any time. The extreme deviation possible being 0·1 foot.

The bell Z, Plate I., was struck by means of the small worm-wheel at every fifty revolutions of the wheel. This bell was held in position by the stand Y, which was placed there to support the indicator of the dynamometer which was originally designed for testing the wheel, but it was used in these experiments only for the purpose of supporting the bell.

A short pipe through the side of the forebay B introduced water into the box *e*, Plate I.; from this it was conveyed by a rubber pipe into the glass tube represented by the side of the scale *d d*, upon which the height of its surface was read.

An iron pipe *f*, perforated near its upper side with 60 holes $\frac{1}{8}$ inch in diameter, rested upon the bottom of the pit and connected by the rubber pipe *g*, with the box *h*, in which the water stood at the height of that in the pit, and this height was read by means of a glass tube directly from the scale *d d*, the zero of which for convenience was placed at the level with the crest of the measuring weir.

The measuring weir K, Plate I., was a notch in a vertical face of plank. The crest was 10·033 feet in length, and 3·26 feet above the bottom of the pit, and had a sharp upstream edge from which it extended horizontally 0·02 foot, and was there scarfed off at an angle of 45°, so that in all the experiments the stream was free from contact after leaving the upstream edge of the crest, until it struck the water several feet below. The end contractions extended 2 feet from the side of the pit, and presented sharp edges beveled off on the down stream side like the crest.

The depth of water upon the weir was measured with a hook gauge in the box *m*, into which water was conducted from the pipe *n*, perforated upon its upper side with a number of small holes, which lay upon the floor near the bottom of the face in which the weir was cut.

A hook being permanently fixed in the box *m*, its height above the crest of the weir was determined by means of the leveling instrument, and the correction for the reading of the hook gauge determined by comparison with this hook.

A small waste gate *p* was used to drain the pit, but this was kept closed during the experiments.

Two fine racks *r r* were placed between the wheel and the weir;

the one farthest down stream being 7 feet from the weir. These were found to completely intercept the whirls in the water as it came out of the wheel and to leave the stream approaching and passing the weir in an undisturbed condition.

Mode of Conducting the Experiments.

Observers were stationed at various points as follows:

Mr. J. B. Hale, at the hook-gauge *m*, observed every minute, and a part of the time every thirty seconds, the reading of the hook-gauge, which indicated the depth of water upon the weir.

Mr. R. A. Hale observed the height of the water in the forebay and in the pit, by means of the scale *d d*, passing from the lower box to the upper every minute.

Mr. E. A. Thissell noted the time of the striking of the bell which indicated the speed of the wheel, to the nearest quarter second.

Mr. James Emerson, by means of the hand-wheel L, regulated the friction so that the index U should be kept as near to zero as possible, and thus the scale beam be kept level.

Another assistant observed as rapidly as possible the actual position of the index during the experiment.

Another kept the oil cups T supplied with oil, and by a cock attached to each, regulated the amount flowing upon the friction surfaces.

Another attended the gate and kept the racks clear of obstructions.

While the writer kept a record of the weights in the scale pan, the heights of gate, all irregularities in the motion or disturbing causes of any kind that would affect the results of the experiment and sufficient observations of each class to check the accuracy of all of the notes.

At intervals during a series of experiments all of the watches were compared with the standard and differences noted, that there might be no difficulty in selecting the observations which applied to the time when the conditions for accurate results obtained.

Before commencing a series of experiments, the apparatus was carefully examined to see if all parts were in proper condition. The link X was removed and the scale beam balanced by attaching or removing small weights from the chain suspending the scale-pan, until a two ounce weight in the scale pan, or at the same distance from the fulcrum in the opposite direction would make the beam move with the same velocity above or below the horizontal position.

The pipes connecting with the gauge boxes were examined to insure free communication.

The height of the hook fixed in the hook-gauge box, above the weir was re-determined, and the reading of the gauge when its hook was level with the hook in the box was observed with much care.

The Data and Results of Experiments.

The data and results of all of the experiments made by the writer upon this wheel are arranged in the following table.

As many of these experiments were made upon days when the public were invited to witness them, and for the accommodation of visitors the conditions of gate and speed were varied through wide ranges in a short time, it has been expedient to record them in an order different from that in which they were taken. Accordingly, the experiments with the same opening of gate are grouped together, and each group arranged in the order of the relation of the speed of the wheel to the velocity due the fall.

As the wheel was put up the set-screws were so adjusted that the gate would open but 5·05 inches, and during the early adjustments this was supposed by the writer to be the full gate, and a nearly complete series of experiments with this and fractional parts of this gate, was made before it became known to him that the opening of the wheel would allow a greater opening of gate. Upon learning this the screws were removed, and the gate opened 5·25 inches, which was as much as the setting of the wheel would allow, although not as much as to include the whole opening of the wheel. It was, however, too late to reset the wheel, as the apparatus had been engaged for use by other parties, and it remained only to make such other experiments as the time and circumstances would allow; for this reason the experiments with gate 5·25 inches open, and the corresponding fractional parts, do not form so complete series as those with the former openings, and the friction bands being somewhat irregularly worn, it was difficult to obtain steady results, when the wheel was heavily loaded, for a sufficient length of time to be entirely satisfactory; still from an examination of the diagram, Plate IV., it will be evident that any fluctuations arising from this cause do not in the extreme case exceed one per cent., and there is no difficulty in determining within a fraction of one per cent. the reliable efficiency of the wheel at any working velocity.

The times of beginning and ending the experiments recorded in column 5, are the times of striking of the bell which include the circumstances of regularity in all departments satisfactory to a reliable result.

Column 6, Duration of the Experiment, is derived directly from column 5.

Column 7, Total number of revolutions of the wheel, is deduced by multiplying the number of intervals indicated by the speed notes between the striking of the bell during the experiment, multiplied by fifty.

Column 8 is deduced directly from 6 and 7.

Column 9, Weight in scale in pounds.

These weights were supplied by the official sealer of weights for the City of Lowell, and were all plainly stamped with their true weight, and after being used were returned to him and again compared with the city standards. The scale beam being accurately balanced, as before described, before each series of experiments, no correction was required.

Column 10, Useful effect, or friction of the brake in pounds raised one foot per second. This is obtained by multiplying together the weight in the scale pan, the leverage of the scale beam, the circumference of the circle containing the point of attachment of the scale beam to the friction band, and the number of revolutions of the wheel per second.

The leverage of the scale beam was 10·00.

The circumference of the point of attachment was 15 feet

Columns 11 and 12 are heights of water above and below the wheel, read from the same scale *dd*, Plate I., and their difference is the fall acting on the wheel given in column 13.

Column 14, Depth of water on the weir, is the depth observed with one of Mr. Francis' hook gauges, described in his Lowell Hydraulic Experiments.

Column 15, Quantity of water passing the weir, is calculated by the formulæ.

$$Q = 3{\cdot}33\,(1 - 0{\cdot}2\ H)\ H^{\frac{3}{2}}$$

$$v = \frac{Q}{S} \qquad h = \frac{V^2}{2\,g},$$

$$H' = \left[(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}} \right]^{\frac{2}{3}},$$

$$Q' = 3{\cdot}33 \; (l - 0{\cdot}2 \; H') \; H'^{\frac{3}{2}}$$

in which—

Q = approximate quantity in cubic feet per second.
l = length of weir in feet.
H = observed depth of water upon the weir in feet.
S = section of the canal leading to the weir $= 14 \times (3{\cdot}26 + H)$.
v = velocity of water in canal leading to the weir.
h = head due this velocity.
H' = depth upon the weir corrected for the velocity due the water approaching the weir.
Q' = quantity of water passing the weir in cubic feet per second.

As there was no leakage into or out of the pit during the experiments, the quantity passing the weir is the quantity acting upon the wheel.

Column 16, Power of the water, is determined by multiplying the quantity of water passing the weir per second, by the fall, and by the weight of a cubic foot of pure water at the temperature given in column 3.

Column 17, Ratio of the useful effect to the power expended, is obtained by dividing column 10 by column 16.

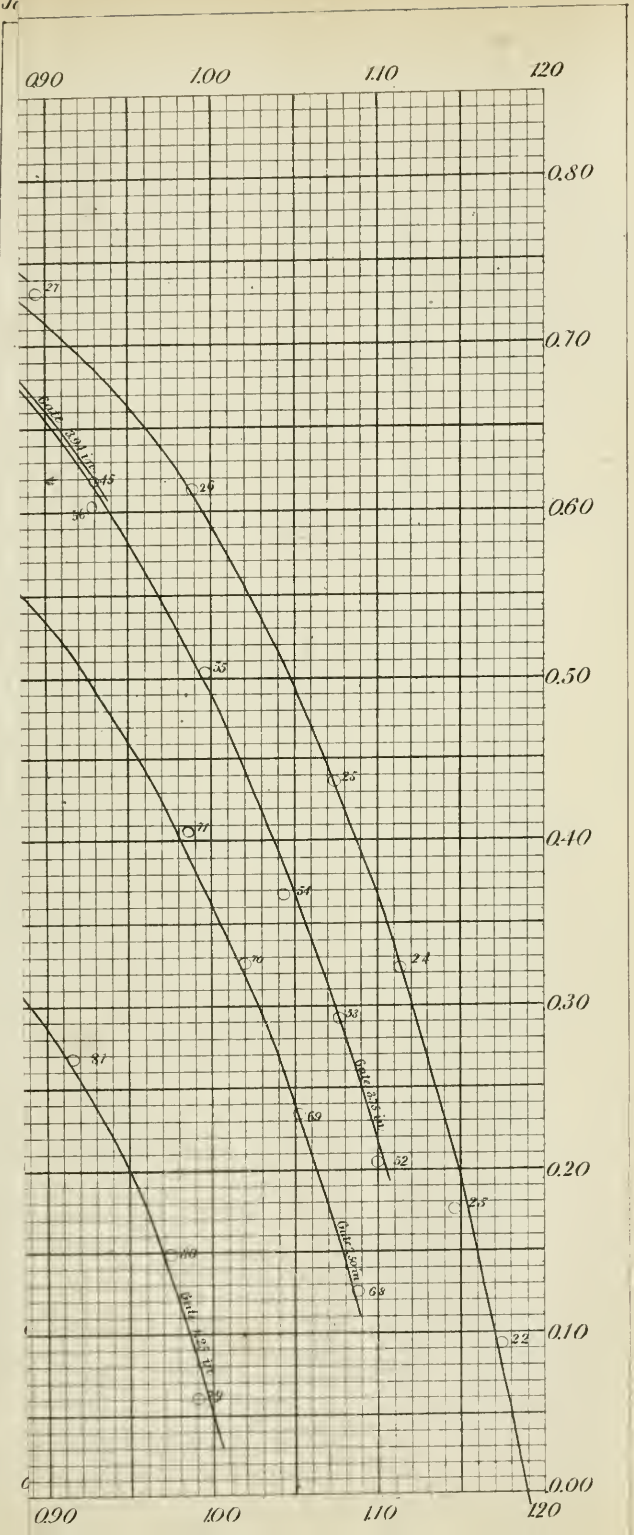
Column 18, Velocity due the fall acting upon the wheel, is determined by the formula $V = \sqrt{2 \, g \, h}$, in which h = fall given in column 13, and $2 \, g = 64{\cdot}3236$.

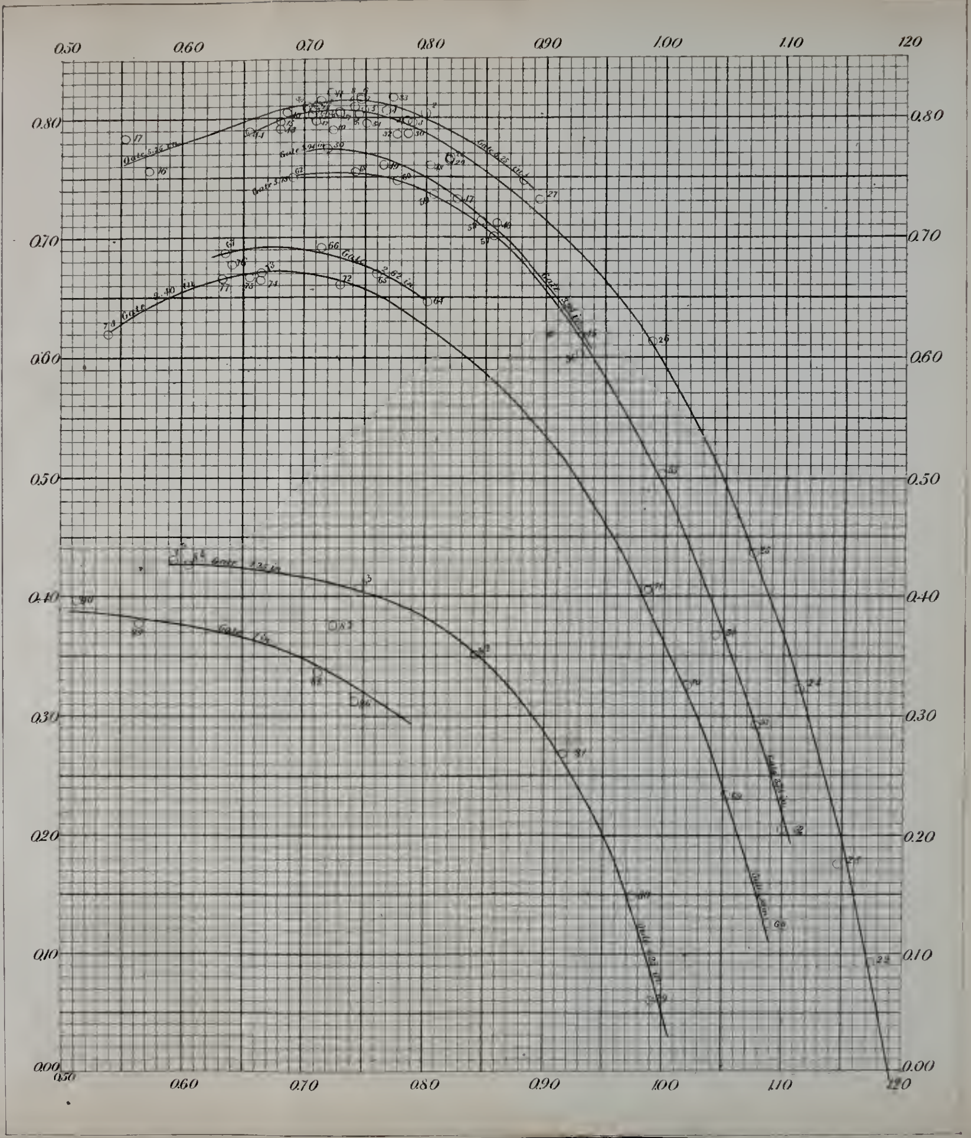
Column 19, Ratio of the velocity of the outer circumference of the wheel to the velocity due the fall.

The outer circumference of the wheel is 10·996 feet, which, multiplied by the number of revolutions per second, divided by the numbers in the last column gives the numbers in this.

The results expressed in this table are presented in diagram in Plate IV., where the ratio of the useful effect to the power expended is represented by the ordinates, and the relative velocity of the wheel and water by the abscissas. The small circles present the conditions of each experiment, and curved lines the mean efficiency at the different velocities deduced from all of the experiments, each

Pl. IV


0.90
1.00
1.10
1.20
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
27
Gate 3.94 in.
45
56
26
55
25
71
54
70
24
53
81
Gate 3.75 in.
69
52
25
Gate 2.50 in.
80
68
Gate 1.25 in.
22
79
0.90
1.00
1.10
1.20


0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Gate 5.26 in.
Gate 3.94 in.
Gate 3.75 in.
Gate 5.25 in.
Gate 2.62 in.
Gate 2.40 in.
Gate 1.25 in.
Gate 1 in.

AT LOWELL, MASS.

1 No. of the Experiment.	13 Total Fall Acting on the Wheel in feet.	14 Depth of Water on the Weir in feet.	15 Quantity of Water which passed the Weir in cubic feet per second.	16 Power of the Water in pounds raised one foot per second.	17 Ratio of the Useful Effect to the Power Expended.	18 Velocity Due to the Fall Acting on the Wheel in feet per second.	19 Ratio of the Velocity of the Exterior Circumference of the Wheel to the Velocity Due to Fall on Wheel.
1	13·195	1·1932	42·880	35225·1	·746	24·134	·881
2	14 283	1 2552	46·230	41118·4	·804	30·318	·800
3	14·217	1·2556	46·255	40950 5	·795	30·244	·789
4	14·215	1·2612	46·560	41214·8	·805	30·238	·766
5	13·208	1·2328	45·005	37607·4	·806	29·148	·750
6	14·265	1·2710	47·150	41883·8	·817	30·291	·746
7	14·260	1·2713	47·190	41904·8	·816	30 286	·746
8	14·260	1 2707	47·110	41833·6	·816	30·286	·745
9	14·260	1·2698	47·030	41762·6	·808	30·286	·742
10	14·219	1·2670	46·882	41511·5	·790	30·242	·724
11	14·255	1·2754	47·345	42027·6	·822	30·280	·721
12	14·233	1·2752	47·335	41953·8	·815	30·257	·714
13	14·275	1·2750	47·318	42062·5	·811	30·302	·712
14	14·230	1·2730	47·212	41825·9	·806	30·254	·710
15	13·175	1 2418	45·500	37320·7	·797	29·111	·681
16	13·178	1·2447	45·820	37591·8	·757	29·114	·574
17	13·250	1·2505	45·980	37929·2	·785	29·194	·554
18	13·495	1·0951	37·740	31715·2	·0	29 463	·0
19	13·119	1·1931	42·875	35026·6	·0	29·048	·0
20	14·220	1·2273	44·720	39599·9	·0	30·244	·0
21	14·195	1·2265	44·770	39574·5	·0	30·217	·0
22	12·240	0·9674	31·375	23916·6	·094	28·059	1·172
23	12·330	0·9901	32·495	24952·5	·177	28·162	1·148
24	12 427	1·0303	34·450	26661·9	·322	28·273	1·115
25	12·608	1·0704	36·476	28641·0	·436	28·478	1·073
26	12 857	1·1308	39·585	31695.3	·612	28·757	·989
27	13·805	1.2043	43·475	37377·6	·731	29·800	·896
28	12·287	1·1824	42·296	32372·9	·768	28·114	·821
29	14·088	1·2366	45·150	39613·4	·765	30·102	·820
30	12·756	1·2098	43·760	34771·5	·786	28·644	·786
31	14·077	1·2518	46 035	40357·5	·797	30·090	·784
32	12·582	1·2042	43·465	34066·0	·787	28·448	·776
33	12·920	1·2228	44·465	35786·0	·816	28·828	·773
34	14·112	1·2586	46·415	40801·8	·794	30·128	·751
35	13 016	1·2334	45·045	36522·2	·804	28·934	·745
36	14·084	1·2650	46·770	41032·3	·804	30·098	·731
37	11·995	1·2052	43·520	32517·8	·804	27·777	·730
38	11·772	1·1955	43·000	31532·0	·802	27·517	·709
39	12·175	1·2089	43·705	33146·1	·808	27·984	·702
40	11·952	1·2040	43 445	32345·4	·802	27·727	·686
41	14·410	1·2745	47·295	42458·8	·803	30·445	·746
42	14·410	1·2787	47·510	42651·8	·796	30·445	·710
43	14·410	1·2860	47·915	46091·8	·791	30·445	·682
44	14·405	1·2862	47·930	43013·9	·789	30·440	·653

TABLE OF EXPERIMENTS UPON THE 42 INCH SWAIN WHEEL AT LOWELL, MASS.

1	2	3	4	5						6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of the Experiment.	Date—June, 1869.	Temperature of the Water—Farenheit.	Height of the Regulating Gate in Inches.	TIME.						Duration of the Experiment in seconds.	Total Number of Revolutions of the Wheel During the Experiment.	Number of Revolutions of the Wheel per second.	Weight in Scale in pounds.	Useful Effect, or the Friction of the Brake in pounds, raised one foot per second.	Height of the Water above the Wheel in feet.	Height of the Water in the Wheel Pit in feet.	Total Fall Acting on the Wheel in feet.	Depth of Water on the Weir in feet.	Quantity of Water which passed the Weir in cubic feet per second.	Power of the Water in pounds raised one foot per second.	Ratio of the Useful Effect to the Power Expended.	Velocity Due to the Fall Acting on the Wheel in feet per second.	Ratio of the Velocity of the Exterior Circumference of the Wheel to the Velocity Due to Fall on Wheel.
				Beginning of the Experiment.			Ending of the Experiment.																
				H.	M.	S.	H.	M.	S.														
1	29	72°	5·25	4	44	27 0	4	48	44·0	257·0	600	2·3346	75·0	26264·3	14·610	1 415	13·195	1·1932	42·880	35225·1	·746	24·134	·881
2	26	70°	“	10	17	26·5	10	22	44 0	317·5	700	2·2047	100·0	33070·5	15·798	1·515	14 283	1 2552	46·230	41118·4	·804	30·318	·800
3	“	“	“	6	35	21·5	6	42	39·5	438·0	950	2·1689	100·0	32535·0	15.714	1·497	14·217	1·2556	46·255	40950 5	·795	30·244	·789
4	“	“	“	6	46	36·0	6	48	11·0	95 0	200	2·1053	105·0	33158·5	15·720	1·505	14·215	1·2612	46·560	41214·8	·805	30·238	·766
5	29	72°	“	11	12	58·0	11	18	50 0	352·0	700	1·9886	100 0	29829·0	14·668	1·460	13·208	1·2328	45·005	37007·4	·806	29·148	·750
6	26	70°	“	10	25	28·0	10	30	44·3	316·3	650	2 0550	111·0	34215·8	15·790	1·525	14·265	1·2710	47·150	41883·8	·817	30·291	·746
7	“	“	“	10	57	26·0	11	0	16·5	170·5	350	2·0528	111·0	34179·1	15·780	1·520	14 260	1·2713	47·190	41904·8	·816	30 286	·746
8	“	“	“	10	52	33·0	10	55	48.0	195·0	400	2·0513	111·0	34154 2	15·770	1·510	14·260	1 2707	47·110	41833 6	·816	30·286	·745
9	“	“	“	8	55	49·0	8	59	53·5	244·5	500	2·0450	110·0	33742·5	15·780	1·520	14·260	1·2698	47·030	41762·6	·808	30·286	·742
10	“	“	“	7	12	9·0	7	18	1·0	352·0	700	1·9886	110·0	32811·9	15·720	1·501	14·219	1·2670	46·882	41511·5	·790	30·242	·724
11	“	“	“	9	45	47·0	9	59	24·0	277·0	550	1·9855	116 0	34547·7	15·785	1·530	14·255	1·2754	47·345	42027·6	·822	30·280	·721
12	“	“	“	9	37	41·5	9	42	47·0	305·5	600	1·9689	116·0	34173·4	15·758	1·525	14·233	1·2752	47·335	41953·8	·815	30·257	·714
13	“	“	“	9	11	1·5	9	12	18 0	76·5	150	1·9608	116·0	34117·9	15·785	1·510	14·275	1·2750	47·318	42062·5	·811	30·302	·712
14	29	72°	“	12	28	49 0	12	30	57·0	128·0	250	1·9531	115 0	33691·0	15·740	1·510	14·230	1·2730	47·212	41825·9	·806	30·254	·710
15	“	“	“	2	55	34·0	2	58	20·5	166·5	300	1·8018	110·0	29729·7	14 640	1·465	13·175	1 2418	45·500	37320·7	·797	29·111	·681
16	“	“	“	4	35	13·5	4	39	37·0	263·5	400	1·5183	125·0	28168·1	14·678	1·500	13·178	1·2447	45·820	37591·8	·757	29·114	·574
17	“	“	“	4	32	0.0	4	33	8·0	68·0	100	1·4706	135·0	29779·7	14 750	1·500	13·250	1·2505	45·980	37929·2	·785	29·194	·554
18	“	“	“	4	22	0·0	4	25	30·0	210·0	0	0·	……	0·	14·840	1·345	13·495	1·0951	37·740	31715·2	·0	29 463	·0
19	“	“	“	11	21	0 0	11	26	0 0	300·0	0	0·	……	0·	14·605	1·486	13·119	1·1931	42·875	35026·6	·0	29·048	·0
20	26	70°	“	7	1	0·0	7	8	0·0	420 0	0	0·	184 0	0·	15 730	1·510	14·220	1·2273	44·720	39599·9	·0	30·244	·0
21	“	“	“	9	18	0·0	9	22	0·0	240·0	0	0·	……	………	15·795	1·600	14·195	1·2265	44·770	39574·5	·0	30 217	·0
22	17	69°	5·05	3	40	2·0	3	43	6·0	184·0	550	2·9891	5·0	2241·8	13·355	1·115	12·240	0·9674	31·375	23916·6	·094	28·059	1·172
23	“	“	“	3	36	4·0	3	39	45·0	221·0	650	2·9410	10.0	4411·5	13·470	1·140	12·330	0·9904	32·495	24952·5	·177	28·162	1·148
24	“	“	“	3	32	9·0	3	35	21·0	192·0	550	2 8646	20·0	8593·7	13·602	1·175	12 427	1·0303	34·450	26661·9	·322	28·273	1·115
25	“	“	“	3	24	39 0	3	29	45·0	306 0	800	2·7778	30·0	12500·0	13 825	1·217	12·608	1·0704	36·476	28641·0	·436	28·478	1·073
26	“	“	“	3	17	32·0	3	23	20 0	348·0	900	2·5862	50·0	19396·5	14·147	1·290	12 857	1·1308	39·585	31695.3	·612	28·757	·989
27	“	“	“	1	2	21·0	1	4	4·0	103·0	250	2·4272	75·0	27306·0	15·195	1.390	13·805	1.2043	43·475	37377·6	·731	29·800	·896
28	16	67°	“	1	40	43·0	1	47	28 0	405·0	850	2·0987	79·0	24869·2	13·643	1·356	12·287	1·1824	42·296	32372·9	·768	28·114	·821
29	17	69°	“	12	44	32 0	12	47	8·0	156·0	350	2.2436	90 0	30288·6	15·523	1·435	14·088	1·2366	45·150	39613·4	·765	30·102	·820
30	16	67°	“	1	29	39·0	1	34	32 0	293 0	600	2·0477	89 0	27337·9	14·148	1·392	12·756	1·2098	43·760	34771·5	·786	28 644	·786
31	17	69°	“	12	36	49·0	12	41	52·0	303 0	650	2·1452	100·0	32178·2	15·535	1·458	14·077	1·2518	46 035	40357·5	·797	30·090	·784
32	16	67°	“	1	34	32·0	1	39	6·0	274·0	550	2·0073	89·0	26797·6	13·962	1·380	12·582	1·2042	43·465	34066·0	·787	28·448	·776
33	“	“	“	1	27	35·0	1	28	49·0	74·0	150	2·0270	96·0	29189 2	14·320	1·400	12·920	1·2228	44·465	35786·0	·816	28·828	·773
34	“	“	“	12	15	30·0	12	19	33·0	243·0	500	2·0576	105 0	32407·2	15·557	1·445	14·112	1·2586	46·415	40801·8	·794	30·128	·751
35	“	“	“	1	19	9·0	1	26	23·0	434·0	850	1·9585	100·0	29377·8	14·473	1·457	13 016	1·2334	45·045	36522·2	·804	28·934	·745
36	“	“	“	12	38	45·0	12	43	45·0	300·0	600	2·0000	110 0	33000·0	15 527	1.443	14·084	1·2650	46·770	41032·3	·804	30·098	·731
37	“	“	“	4	38	43·0	4	46	22·0	459·0	800	1·7430	100·0	26145·0	13·362	1·367	11·995	1·2052	43·520	32517·8	·804	27·777	·730
38	“	“	“	5	3	26·0	5	8	36·0	310 0	550	1·7742	95 0	25282·4	13 142	1·370	11·772	1·1955	43·000	31532·0	·802	27·517	·709
39	“	“	“	4	37	19·0	4	40	35·0	196·0	350	1·7857	100 0	26785·5	13·540	1·365	12·175	1·2089	43·705	33146·1	·808	27·984	·702
40	“	“	“	4	40	35·0	4	46	22·0	347·0	600	1·7291	100·0	25936·0	13·320	1·368	11·952	1·2040	43·445	32345·4	·802	27·727	·686
41	12	“	5 00	8	5	3·0	8	10	18·0	315·0	650	2·0635	109·75	34092·7	15·750	1·340	14·410	1·2745	47·295	42458·8	·803	30·445	·746
42	“	“	“	8	19	2·0	8	22	51·0	229·0	450	1·9650	114·75	33944·3	15·750	1·340	14·410	1·2787	47·510	42651·8	·796	30·445	·710
43	“	“	“	8	33	30·0	8	38	48 0	318·0	600	1·8868	119·75	34013·6	15·750	1·340	14·410	1·2860	47·915	46091·8	·791	30·445	·682
44	“	“	“	8	44	10·0	8	48	19·0	249 0	450	1·8072	124·75	33939·0	15·750	1·345	14·405	1·2862	47·930	43013·9	·789	30·440	·653

1	13	14	15	16	17	18	19
No. of the Experiment.	Total Fall acting on the Wheel in feet.	Depth of Water on the Weir in feet.	Quantity of Water which passed the Weir in cubic feet per second.	Power of the Water in pounds raised one foot per second.	Ratio of the useful effect to the power expended.	Velocity due to the Fall acting on the Wheel in feet per second.	Ratio of the Velocity of the exterior circumference of the Wheel to the velocity due to fall on Wheel.
45	13 777	1·0509	35·480	18828 8	.619	29·769	·928
46	13·721	1·0859	37·210	31785 8	·711	29·708	·858
47	13·590	1·0928	37·605	31820·8	·732	29·566	·825
48	13·330	1·1050	38·238	31733·2	·758	29 282	·803
49	13·355	1·1126	38·640	32126·9	·760	29·310	·764
50	14·452	1·1460	40·380	36331·4	·775	30·490	·720
51	13 245	1·1006	38·009	31349·6	·0	29·189	·0
52	11·779	0·8870	27·570	20085·7	·204	27·526	1·100
53	11·710	0·9050	28·405	20715·1	·292	27·445	1·077
54	11 650	0·9208	29·150	21149·4	·368	27·375	1·044
55	11·610	0·9520	30·620	22139·7	·503	27·328	·996
56	11·800	0·9867	32·300	23736·7	·603	27·550	·929
57	11·937	1·0236	34·115	25361·5	·701	27·710	·856
58	12·470	1·0512	35·500	27575·7	·713	28·322	·848
59	12·205	1·0554	35·710	27371·8	·736	28·133	·807
60	12 457	1·0656	36·225	28109·6	·747	28·306	·777
61	12·552	1.0740	36·665	28668·5	·752	28·414	·742
62	12·207	1·0795	36 910	28089·1	·751	28·020	·690
63	11·520	1·1520	40·690	29189·9	·0	27·221	·0
64	13·910	0·9210	29·160	25252 4	·648	29·912	·862
65	14 710	0·9629	31·130	28515·7	·670	30 760	·759
66	14 705	0·9730	31·630	28963·9	·692	30·755	·713
67	14.675	0·9831	32·120	29352·6	·689	30·720	·635
68	12 042	0·7623	22·000	16499·0	·125	27·832	1 089
69	12·007	0·7830	22·850	17087·3	·233	27·784	1·051
70	12·042	0·8004	23·660	17743·9	·326	27·831	1·016
71	12 090	0·8178	24·410	18379·3	·408	27·887	·986
72	12 243	0·8934	27·800	21195·8	·659	28·062	·730
73	13·041	0·9191	29·080	23623·7	·670	28·964	·668
74	12·038	0·8949	27·920	20429·7	·664	27·827	·666
75	12·200	0·8998	28·135	21376·7	·667	28 013	·654
76	12·114	0 8999	28·140	21229·8	·677	27·914	·640
77	12·750	0·9154	28·910	22960·5	·666	28 637	·631
78	11·960	0 9011	28·220	21019·4	·620	27·725	·538
79	12·270	0 6191	16.150	12341·0	·061	27·808	·990
80	12·258	0 6283	16·500	12595·1	·148	28·079	·974
81	12·265	0·6440	17·130	13084·6	·267	28·087	·912
82	12·297	0·6601	18·000	13785·0	·351	28·125	·841
83	12·354	0·6709	18·295	14076·0	·408	28·189	·747
84	13·379	0·6571	17·660	14714·6	·427	29·336	·605
85	13·480	0·6613	17·810	14917·3	·430	29·446	·592
86	14·957	0·6214	16·230	15118·1	·312	31·018	·743
87	15 048	0 6285	16 510	15472·5	·378	31·112	·726
88	15·024	0·6246	16·370	15316·8	·336	31·087	·714
89	12·729	0·5837	14·780	11715 9	·377	28·614	·566
90	12·200	0 5866	14·880	11305 7	·398	29·139	·514

TABLE OF EXPERIMENTS UPON THE 42 INCH SWAIN WHEEL AT LOWELL, MASS.

1	2	3	4	5						6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of the Experiment.	Date—June, 1869.	Temperature of the Water—Fahrenheit.	Height of the Regulating Gate in inches.	TIME.						Duration of the Experiment in seconds.	Total number of Revolutions of the Wheel during the Experiment.	Number of Revolutions of the Wheel per second.	Weight in Scale in pounds.	Useful Effect or the Friction of the brake in pounds raised one foot per second.	Height of the water above the wheel in feet.	Height of the Water in the Wheel Pit in feet.	Total Fall acting on the Wheel in feet.	Depth of Water on the Weir in feet.	Quantity of Water which passed the Weir in cubic feet per second.	Power of the Water in pounds raised one foot per second.	Ratio of the useful effect to the power expended.	Velocity due to the Fall acting on the Wheel in feet per second.	Ratio of the Velocity of the exterior circumference of the Wheel to the velocity due to fall on Wheel
				Beginning of the Experiment.			Ending of the Experiment.																
				H.	M.	S.	H.	M.	S.														
45	29	72°	3·937	2	35	40·0	2	39	39·0	239 0	600	2·5105	50·0	30431·7	14·977	1·200	13 777	1·0509	35·480	18828 8	.619	29·769	·928
46	"	"	"	4	3	25·0	4	15	17·0	712 0	1650	2·3174	65·0	22594·7	14·982	1·261	13·721	1·0859	37·210	31785 8	·711	29·708	·858
47	"	"	"	4	17	8·0	4	21	16·0	248·0	550	2·2180	70·0	23289·0	14·865	1·275	13·590	1·0928	37·605	31820·8	·732	29·566	·825
48	"	"	"	11	40	5 0	11	43	59 0	234·0	500	2·1368	75·0	24039·0	14·615	1·285	13·330	1·1050	38·238	31733·2	·758	29 282	·803
49	"	"	"	11	47	30 0	11	50	22 0	172·0	350	2·0349	80·0	24418·8	14·650	1·295	13·355	1·1126	38·640	32126·9	·760	29 310	·764
50	"	"	"	12	17	8·5	12	22	34 0	325·5	650	1·9969	94·0	28156·3	15·787	1·335	14·452	1·1460	40·380	36331·4	·775	30·490	·720
51	"	"	"	11	28	0·0	11	31	0·0	360·0	0	0·	·0	·0	14·610	1·365	13 245	1·1006	38·009	31349·6	·0	29·189	·0
52	17	69°	3·750	4	59	16·0	5	1	5·0	109 0	300	2 7522	10 0	4128·3	12·772	0 993	11·779	0·8870	27·570	20085·7	·204	27·526	1·160
53	"	"	"	5	2	37·0	5	4	10·0	93·0	250	2·6882	15·0	6048·4	12·730	1 020	11·710	0 9050	28·405	20715·1	·292	27·445	1·077
54	"	"	"	5	6	7·0	5	7	24·0	77·0	200	2·5974	20·0	7792·2	12·695	1·045	11 650	0·9208	29·150	21149·4	·368	27·375	1·044
55	"	"	"	5	8	4 0	5	9	45 0	101·0	250	2·4753	30·0	11138·6	12·687	1·077	11·610	0·9520	30·620	22139·7	·503	27·328	·996
56	"	"	"	3	54	47·0	3	57	39·0	172·0	400	2·3256	41 0	14302·4	12·910	1·110	11·800	0·9867	32·300	23736 7	·603	27·550	·929
57	"	"	"	3	49	48·0	3	53	40·0	232·0	500	2·1552	55·0	17780·4	13·087	1·150	11·937	1·0236	34·115	25361·5	·701	27·710	·856
58	16	67°	"	4	3	4·0	4	14	8·0	664·0	1450	2·1837	60·0	19653·3	13·643	1·173	12·470	1·0512	35·510	27575·7	·713	28·322	·848
59	"	"	"	3	38	33·0	3	44	12·0	339 0	700	2·0649	65·0	20132·8	13·490	1·185	12·305	1·0554	35·710	27371·8	·736	28·133	·807
60	"	"	"	3	33	8·0	3	37	18·0	250·0	500	2·0000	70·0	21000·0	13·647	1·190	12 457	1·0656	36·225	28109·6	·747	28·306	·777
61	"	"	"	3	20	3·0	3	25	42 0	339 0	650	1·9174	75·0	21570·8	13·775	1·203	12·552	1.0740	36·665	28668·5	·752	28·414	·742
62	"	"	"	11	22	0·0	11	25	19·0	199·0	350	1·7588	80·0	21105·6	13·412	1·205	12·207	1·0795	36 940	28089·1	·751	28·020	·690
63	"	"	"	5	22	0·0	0	0	0·0	·0	0	0·	·0	·0	12·950	1·430	11·520	1·1520	40·690	29189·9	·0	27·221	·0
64	29	72°	2·625	10	55	8·5	11	3	10 0	481·5	1050	2·1807	50·0	16355·3	14·940	1·030	13·910	0·9210	29·160	25252 4	·648	29·912	·802
65	26	70°	"	6	1	24·5	6	6	30·5	306 0	650	2·1240	60·0	19116·0	15·810	1·100	14 710	0·9629	31·130	28515·7	·670	30 760	·759
66	"	"	"	6	11	54·2	6	16	55·0	300·8	600	1·9947	67·0	20046·7	15·810	1·105	14 705	0·9730	31·630	28963·9	·692	30·755	·713
67	"	"	"	6	19	36·0	6	22	53·2	197·2	350	1·7748	76·0	20232·5	15·805	1·130	14.675	0·9831	32·120	29352·6	·689	30 720	·635
68	17	69°	2·500	4	54	19·0	4	56	8·0	109·0	300	2·7522	5·0	2064·2	12·885	0·843	12 042	0·7623	22·000	16499·0	·125	27·832	1·089
69	"	"	"	4	52	8·0	4	51	1·0	113·0	300	2·6548	10·0	3982·2	12·880	0 873	12 007	0·7830	22·850	17087·3	·233	27·784	1·051
70	"	"	"	4	48	54 0	4	51	49·0	175·0	450	2·5714	15·0	5785·7	12·930	0·888	12·042	0·8004	23·660	17743·9	·326	27·831	1·016
71	"	"	"	4	45	34·0	4	48	34·0	180·0	450	2·5000	20·0	7500 0	12·980	0·890	12 090	0·8178	24·410	18379·3	·408	27·887	·986
72	15	70°	"	3	37	52·0	3	44	35·0	403·0	750	1·8610	50·0	13957·5	13·178	0 935	12 243	0·8934	27·800	21195·8	·659	28·062	·730
73	16	67°	"	10	31	47·0	10	38	25·0	398·0	700	1·7587	60·0	15828·3	14·040	0·999	13·041	0·9191	29·080	23623·7	·670	28·964	·668
74	15	70°	"	4	23	15 0	4	29	41·0	386·0	650	1·6839	55·0	13892·2	12·972	0·934	12·038	0·8949	27·920	20429·7	·664	27·827	·666
75	"	"	"	4	47	12 0	4	50	42 0	210·0	350	1·6666	57·0	14249 4	13·133	0·933	12·200	0·8998	28 135	21376·7	·667	28 013	·654
76	"	"	"	4	51	13·0	4	56	21 0	308·0	500	1·6233	59 0	14366 2	13 050	0·936	12 114	0 8999	28·140	21229·8	·677	27·914	·640
77	16	67°	"	10	43	45 0	10	47	18·0	213·0	350	1 6432	62·0	15281·6	13 748	0·998	12·750	0·9154	28·910	22960·5	·666	28 637	·631
78	15	70°	"	5	9	27·0	5	13	45·0	258·0	350	1·3565	64 0	13082·5	12·897	0 937	11·960	0 9011	28·220	21019·4	·620	27·725	·538
79	17	69°	1·250	4	30	32·0	4	33	30·0	178·0	450	2·5280	2·0	758·4	12·945	0·675	12·270	0 6191	16.150	12341·0	·061	27·808	·999
80	"	"	"	4	26	52·0	4	29	33·0	181·0	450	2·4861	5 0	1864·6	12·943	0·685	12·258	0 6283	16·500	12595·1	·148	28·079	·974
81	"	"	"	4	21	10·0	4	25	49·0	279 0	650	2·3297	10 0	3494·6	12·960	0·695	12·265	0·6440	17·130	13084·6	·267	28·087	·912
82	"	"	"	4	14	35·0	4	20	47·0	372 0	800	2·1505	15·0	4838·6	13·008	0·711	12·297	0·6601	18·000	13785·0	·351	28·125	·841
83	"	"	"	4	9	10 0	4	13	47·0	277·0	550	1·9133	20 0	5739 9	13 076	0·722	12·354	0·6709	18·295	14076·0	·468	28·189	·747
84	15	70°	"	6	3	50·0	6	7	58·0	248 0	400	1·6129	26·0	6290·2	14·072	0·693	13·379	0·6571	17·660	14714·6	·427	29·336	·605
85	"	"	"	6	8	59 0	6	13	43·0	284·0	450	1·5845	27·0	6417·2	14·176	0·696	13·480	0·6613	17 810	14917·3	·430	29·446	·592
86	"	"	1·600	12	13	48·0	12	23	45·0	597·0	1250	2·0938	15·0	4711·1	15·695	0·738	14·957	0·6214	16·230	15118·1	·312	31·018	·743
87	"	"	"	12	35	22·0	12	48	45 0	803·0	1650	2·0547	19·0	5855·9	15·728	0·680	15 048	0 6285	16 510	15472·5	·378	31·112	·726
88	"	"	"	12	25	48·0	12	32	49·0	421·0	850	2·0190	17·0	5148 5	15·735	0·711	15·024	0·6246	16·370	15316·8	·336	31·087	·714
89	"	"	"	2	35	11·0	2	48	46 0	815·0	1200	1·4723	20·0	4416·9	13·344	0 615	12·729	0·5837	14·780	11715 9	·377	28·614	·566
90	"	"	"	2	50	35 0	2	58	32·0	477·0	650	1·3626	22·0	4496·6	13·133	0·933	12·200	0 5866	14·880	11305 7	·398	29·139	·514

line corresponding to the opening of gate expressed at its extremities.

From these curves it will be seen that the mean maximum efficiency of the wheel is as follows, viz:

With full gate 81$\frac{3}{10}$ per cent. of the power of the water. With three-quarters gate 77$\frac{3}{10}$ per cent. of the power of the water; and with one-half gate 69$\frac{3}{10}$ per cent. of the power of the water.

Essex Company's Office, Lawrence, Jan. 26, 1870.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 119.)

Telodynamic Transmission—continued.

We do not consider our collection of facts, concerning this novel and interesting method of transmitting power, as complete without the following notes, which we transcribe from the excellent little treatise on the subject by Mr. W. A. Roebling, C. E., and published by Mr. D. Van Nostrand, 23 Murray Street, New York, 1869.

"In point of economy it costs only one-fifteenth of an equivalent amount of belting, and the one-twenty-fifth of shafting. * *

"The range in the size of wire ropes is small, varying only from $\frac{3}{8}$ inch to $\frac{3}{4}$ inch diameter in a range of 3 to 250 horse-power. *

"In regard to cost, the ropes are the cheapest part of a transmission. For instance, a No. 22 rope, conveying say 25 horse-power, costs 8 cents per foot, whereas an equivalent belt costs about $1.40 per foot. * * * Their duration is from 2½ to 5 years, according to the speed.

"For the smaller powers it is advisable to take a size larger, for the sake of getting wear out of the rope: although it must be borne in mind that a larger rope is always stiffer than a small one, and therefore additional power is lost in bending it around the sheave. An illustration of that is seen in the case of the 14 feet wheel in the table, where a $\frac{7}{8}$ rope gives less power than a $\frac{3}{4}$ rope, simply because it is so much stiffer.

"Ropes for this purpose are always made with a hemp core, to increase their pliability.

"It is often required to convey the entire power of a certain

TABLE OF TRANSMISSION OF POWER BY WIRE ROPES.

Diam. of Wheel in feet	No. of Rev.	Trade No. of Rope.	Diam. of Rope.	Horse Power.	Diam. of Wheel in Feet.	No. of Rev.	Trade No. of Rope.	Diam. of Rope.	Horse Power.
4	80	24	$\frac{3}{8}$	3·3	10	80	19 18	$\frac{5}{8}$ $\frac{11}{16}$	55· 58·4
4	100	24	$\frac{3}{8}$	4·1	10	100	19 18	$\frac{5}{8}$ $\frac{11}{16}$	68·7 73·
4	120	24	$\frac{3}{8}$	5·	10	120	19 18	$\frac{5}{8}$ $\frac{11}{16}$	82·5 87·6
4	140	24	$\frac{3}{8}$	5·8	10	140	19 18	$\frac{5}{8}$ $\frac{11}{16}$	96·2 102·2
5	80	23	$\frac{7}{16}$	6·9	11	80	19 18	$\frac{5}{8}$ $\frac{11}{16}$	64·9 75·5
5	100	23	$\frac{7}{16}$	8·6	11	100	19 18	$\frac{5}{8}$ $\frac{11}{16}$	81·1 94·4
5	120	23	$\frac{7}{16}$	10·3	11	120	19 18	$\frac{5}{8}$ $\frac{11}{16}$	97·3 113·3
5	140	23	$\frac{7}{16}$	12·1	11	140	19 18	$\frac{5}{8}$ $\frac{11}{16}$	113·6 132·1
6	80	22	$\frac{15}{32}$	10·7	12	80	18 17	$\frac{11}{16}$ $\frac{3}{4}$	93·4 99·3
6	100	22	$\frac{15}{32}$	13·4	12	100	18 17	$\frac{11}{16}$ $\frac{3}{4}$	116·7 124·1
6	120	22	$\frac{15}{32}$	16·1	12	120	18 17	$\frac{11}{16}$ $\frac{3}{4}$	140·1 148·9
6	140	22	$\frac{15}{32}$	18·7	12	140	18 17	$\frac{11}{16}$ $\frac{3}{4}$	163·5 173·7
7	80	22	$\frac{15}{32}$	16·9	13	80	18 17	$\frac{11}{16}$ $\frac{3}{4}$	112· 122·6
7	100	22	$\frac{15}{32}$	21·1	13	100	18 17	$\frac{11}{16}$ $\frac{3}{4}$	140· 153·2
7	120	22	$\frac{15}{32}$	25·3	13	120	18 17	$\frac{11}{16}$ $\frac{3}{4}$	168· 183·9
7	140	22	$\frac{15}{32}$	29·6	14	80	17 16	$\frac{3}{4}$ $\frac{7}{8}$	148· 141·
8	80	21	$\frac{1}{2}$	22·	14	100	17 16	$\frac{3}{4}$ $\frac{7}{8}$	185· 176·
8	100	21	$\frac{1}{2}$	27·5	14	120	17 16	$\frac{3}{4}$ $\frac{7}{8}$	222· 211·
8	120	21	$\frac{1}{2}$	33·	15	80	17 16	$\frac{3}{4}$ $\frac{7}{8}$	217· 217·
8	140	21	$\frac{1}{2}$	38·5	15	100	17 16	$\frac{3}{4}$ $\frac{7}{8}$	259· 259·
9	80	20 19	$\frac{17}{32}$ $\frac{5}{8}$	40· 41·5	15	120	17 16	$\frac{3}{4}$ $\frac{7}{8}$	300· 300·
9	100	20 19	$\frac{17}{32}$ $\frac{5}{8}$	50· 51·9					
9	120	20 19	$\frac{17}{32}$ $\frac{5}{8}$	60· 62·2					
9	140	20 19	$\frac{17}{32}$ $\frac{5}{8}$	70· 72·6					

shaft which is driven by a belt of a given size. In such a case, a simple rule, agreeing with the average result of practice, is, that 70 square feet of belt surface are equal to one horse-power.

"Take, for example, a belt 1 foot wide running at the rate of 1400 feet per minute: then the horse-power $= \frac{1400 \times 1}{70} = 20$; and by referring to the table we find the diameter of the wheel corresponding to this horse-power, and making the same number of revolutions that the belt-pulley does.

Distance of Transmission.

"The foregoing table is intended for distances from 80 up to 350 or 400 feet in one stretch. For a single stretch extended to say 450 feet, where no opportunity is presented for putting in an intermediate station, we must use a rope one size heavier; and in a case where there is not sufficient head-room to allow the rope its proper sag, and it has to be stretched tighter in consequence, we must also take a rope one size heavier.

Short Transmission.—"Whenever the distance is less than 80 feet, the rope has to be stretched *very tight*, and we no longer depend upon the sag to give it the requisite amount of tension. Here we must take a rope two sizes heavier than is given in the table, and run at the maximum speed indicated; it is also preferable to substitute in place of the rope of 49 wires, a fine rope of 133 wires of the same diameter, which possesses double the flexibility, runs smoother, and lasts longer. In fact, the substitution of a fine rope for a coarse one can be done with advantage in every case in the table where the size admits of it.

Splices.—"Both kinds of rope are spliced with equal facility. The splices are all of the kind known as the long-splice; the rope is not weakened thereby, neither is its size increased any, and only a well practised eye can detect the locality of one.

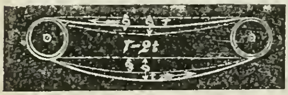
Relative Height of Wheels.—"It is not necessary that the two wheels should be at the same level, one may be higher or lower than the other without detriment; and unless this change of level is carried to excess, there need be no change in the size of wheel or speed of rope: the rope may have to be strained a little tighter. As the inclination from one wheel to another approaches an angle of 45°, a different arrangement must be made, as will be shown hereafter.

Deflection or Sag of the ropes.

"In the following illustration the upper rope is the pulling-rope and the lower one the loose following rope. When the rope is working, the tension T in the upper rope is just double that in the lower rope, hence the latter will sag much lower below a horizontal line than the upper one.

"When the rope is at rest, both ropes will occupy the position indicated by the dotted line, and will have a uniform tension.

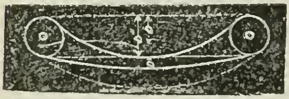
The best way in practice is to hang up a wire in the position the rope is to occupy at rest: that has to be done in any case, in order to get the length of rope needed. Then hang it so that the deflection *d′*, below the horizontal line, is about $\frac{1}{35}$th of the whole distance from wheel to wheel. The deflection *d* of the upper running-rope will then be about $\frac{1}{45}$th to $\frac{1}{50}$th.



"The deflection *d″* of the lower working-rope is on an average one-half greater than the deflection *d′* of the rope at rest. This is of importance, as we should know beforehand whether the lower rope is going to scrape on the ground or touch other obstructions; in that case, we either have to dig a trench for the lower rope to run in or else raise both wheels high enough to clear.

"Practically, however, it is not necessary to be so particular about this matter, on account of the stretch in the rope. Wire-rope stretches, comparatively, very little; still there is some stretch; and it is well to allow for it by stretching the rope a little too tight at first. After running a little it will hang all right. When the rope is very long it is advisable to take up the stretch at the end of two or three months, as a slack rope does not run as steadily as a tight one.

"Whenever the direction of the motion of the driving-wheel is not fixed by other circumstances, it is often advisable to make the lower rope the pulling rope, and the upper the follower, as here shown. In this way obstructions can be avoided, which, by the other plan, would have to be removed. The ropes will not interfere as long as the difference between the two deflections *d′* and *d″* is less than the diameter of the wheel.



"These limits are of use whenever, on account of rocks or otherwise, we have to move the wheels closer together, and the question is, how far to have them apart with a certain deflection."

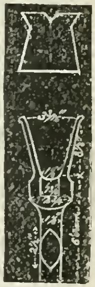
The Wheels.

"The bottom of the groove in the wheels is made a little wider to prevent the filling from flying out. The rope should always move on a cushion of some kind, and not on the iron, which quickly wears it out.

"A variety of material is used for this filling—soft wood, india-rubber, leather, old rope tarred and oakum.

"To use end wood the rim has to be constructed on a different plan from that shown here. The objections to it are that it is liable to shrink, and crack and fly out; it is also more severe on the rope. India-rubber is a very good material; strips of an inch square or less can be wedged in very quickly, and will last a long time; the price, however, is 50 to 60 cents per pound, which is rather against it.

"My own practice has been to use leather, also rope and oakum. The leather is cut in sections of this shape, and set in on end around the rim; scraps can be used, cut from old shoes, pieces of leather-belting, etc.; they are very thin, and it takes at least a thousand for a 7-foot wheel. When many are wanted, it is worth while to make a die to cut them out fast. This is the most durable filling that can be made.



"Again, by wedging the groove full of tarred oakum a filling is also obtained, nearly as good as leather, costing less, and not so tedious to put in. Another plan, which I have tried with success, is to revolve the wheels slowly and let a lot of small-sized tarred ratlin or jute-yarns wind up on themselves in the groove; then secure the end, and after a day or two of running the pressure of the rope, together with the tar, will have made the filling compact. This makes a cheap filling.

"The double-grooved wheels are filled in the same way.

"The rope will run on such filling without making any noise whatever, and soon wears in a round groove for itself.

"A section of the rim of a 6-foot wheel is here shown with the dimensions marked.

"The diameter of the wheel is not reckoned from the outside of the rim, but from the top of the filling, which corresponds to the circle described by the rope. The hub is made of ample size, so as to admit of being bored out for shafts, ranging from 2 to 3½ inches.

* * * * "The rope while running requires no protection from the weather. If it has to stand still much, pour some hot coal tar on the rope in the groove of the wheel while running.

"Whenever there is no room for the sag of the rope, and it is inconvenient to raise the wheels higher, or a ditch cannot be dug, it

TABLE OF WIRE ROPE, MANUFACTURED BY JOHN A. ROEBLING, TRENTON, N. J.

ROPE OF 133 WIRES.

Trade Number	Circumference in inches.	Diameter.	Price per foot, in cents.	Ultimate strength in tons of 2,000 lbs.	Circumference of Hemp Rope of equivalent strength in inches.
1	6¾	2¼	1 20	74 00	15½
2	6	2	1 05	65 00	14½
3	5½	1¾	91	54 00	13
4	5	1⅝	78	43 60	12
5	4⅜	1½	65	35 00	10¾
6	4	1¼	53	27 20	9½
7	3½	1⅛	41	20 20	8
8	3⅛	1	34	16 00	7
9	2¾	⅞	28	11 40	6
10	2¼	¾	25	8 64	5
10¼	2	⅝	24	5 13	4½
10½	1⅝	9/16	23	4 27	4
10¾	1½	½	22	3 48	3¾

Tiller Rope, ⅝ in. diam., 26 cents.

Ropes from No. 8 to No. 10¾, are specially adapted for hoisting-rope.

Steel rope of all sizes made to order.

All kinds of shackles, sockets, swivel hooks, and fastenings put on and splices made.

ROPE OF 49 WIRES.

Trade Number.	Circumference in inches.	Price per Foot, in cents.	Ultimate strength in tons of 2,000 lbs.	Circumference of Hemp Rope of equivalent strength in inches.
11	4⅝	54	36 00	10¾
12	4¼	47	30 00	10
13	3¾	41	25 00	9½
14	3⅜	35	20 00	8¼
15	3	29	16 00	7¼
16	2⅝	23	12 30	6¼
17	2⅜	18	8 80	5½
18	2⅛	15	7 60	5
19	1⅞	13	5 80	4¾
20	1⅝	11	4 09	4
21	1⅜	9	2 83	3¼
22	1¼	8	2 13	2¾
23	1⅛	7	1 65	2½
24	1	6½	1 38	2¼
25	⅞	6	1 03	2
26	¾	5½	0 81	1¾
27	⅝	5	0 56	1½
27½	½	4		
28		3	Large Sash Cord.	
29		2	Small "	

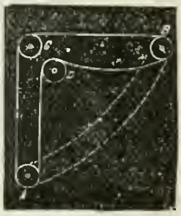
Copper Rope corresponding to the above sizes, made to order.

may be supported by a roller in the middle. This supporting roller must be in the centre of the span, and must be at least half the size of the larger wheels." * * * * * *

"Transmissions are in operation a mile in length. The loss of power from friction, etc., or bending of rope, does not amount to 10 per cent. per mile, and need not be taken into account at all for only one station. No slipping of the rope in the groove ever occurs with a proper filling.

"With bearings of a sufficient length under the shaft of the centre wheel, and by providing them with a self-feeding oil cup, the axle-friction is reduced to a minimum. * * * *

"When the power is to be conveyed nearly vertically, no good result is obtained by running the rope, say from *a* to *b*, direct, as indicated by dotted lines in the figure below, since it would slip. Two carrying sheaves, *c* and *d*, must be put up vertically above *a*, giving a horizontal stretch from *c* and *d* to *b*. This is necessary, in order to maintain the required tension in the rope, which can be obtained in no other way. *a*, *b*, and *c*, and even *d*, should be of the same size; yet *d*, which supports the following rope, may be made smaller without damage.



"This arrangement must be borne in mind whenever the source of power is located in the cellar, and we want to carry it to the upper story and distribute it horizontally.

We conclude by giving the wire rope table in full, to which reference is made in the preceding notes.

(To be continued.)

Artificial Porphyry from Iron Slags.—At the iron works of Aulnoye, in Belgium, the slag is utilized by casting it into slabs for pavements, garden rollers and other things.

Paper is made by a company in Norfolk, Va., from the fibres of the reed cane, by discharging the cane from a tube or gun by steam, at 200 pounds pressure, by which the resin and gums are rendered soluble in water without the use of chemicals. This process is an old one as applied to wood, but may prove more successful when applied to this new material.

PENNSYLVANIA R. R. BRIDGE OVER 30TH STREET, PHILADELPHIA.

By Jos. M. Wilson, C. E.—P. A. Engineer, Construction Dep't, Penn'a R. R.

This bridge was constructed from a design of the writer for the purpose of carrying the Railroad tracks over 30th Street to the upper story of the extensive Grain Depot recently erected by the Pennsylvania Railroad Company at that point.

The amount of clear headway, from the street grade to base of rail was very limited, and it was considered objectionable to have a through bridge with the trusses above the floor line.

The greatest clear height, under the bridge, was required over the carriage way, the foot ways did not require so much. The street being a main thoroughfare of the city, and one of the principal drives to the new Fairmount Park, it became essential to have something neat and artistic in design and finish. These considerations led to the adoption of the arch form of bridge, and since the limited thickness of the stone abutment, next to the Grain Depot building, required the thrust of the arch to be thrown on to the stone work some distance down from the top of the abutment, thus excluding any form of segmental arch that would allow sufficient height above the footways, we finally decided upon a "Wrought Iron Elliptical Braced Arch," the upper chord, or boom, being horizontal. The bracing pieces are stiffened at their middle points in the direction of the length of the bridge, by curved members running through the structure as shown in the drawings. The arch is hinged both at the crown and springing, by this means reducing the calculations to a certainty not possessed by the ordinary form of arch, and annulling the straining effects due to change of temperature or yielding of piers. The braces are connected to the arch member and upper chord by pins. There are six tracks and twelve trusses, two to each track. The trusses are connected together by lateral bracing, both in the arch member, and upper chord, but there is no diagonal bracing, the ends of upper chord being secured in masonry so as to allow longitudinal, but not lateral motion. The floor beams are of wrought iron I section, and the track stringers of white oak. There is a flooring of two inch plank laid with an incline to properly drain off the water and covered with tarred sheet iron. On each side of the bridge is a galvanized iron cornice and wrough iron railing.

The hinge blocks at crown and springing, some ferrules in upper chord in centres of panels, and a few washers and rosettes are the only castings in the structure.

The following are the principal dimensions and assumed data:—

Span, centre to centre of pins at springing	64 feet 1 inch.
Height from springing line to centre of pier at crown	11 " $11\frac{3}{4}$ "
Length of panel in bracing	4 " $0\frac{1}{16}$ "
Number of trusses	12
Number of tracks	6
Distance of trusses apart, centre to centre	10 feet 0 inches.
" " tracks " "	20 " 0 "
Upper chord projects at each end beyond centre of end pin	5 "
Total length of upper chord out to out	64 " 11 "
Variable load per foot lineal of each track	3,000 lbs.
" " " truss	1,500 "
Constant load = weight of bridge per foot lineal of each truss	500 "
Total load per foot lineal of each truss	2,000 "

The strains upon the different members of the structure were solved graphically, the forces being taken as applied at the points of connection of the braces with the upper chord.

The total force or load at each point, except at the ends of truss, was taken at 2,000 lbs. × 4 = 8,000 lbs. = 4 tons, and at the ends 2,000 lbs. × 2 = 4,000 lbs. = 2 tons.

The diagram of strains for each force was constructed separately and the results tabulated, compressive strains being represented positive, and tensive negative.

The arch being symmetrical it was necessary to compute for only one side, and to construct diagrams for only the forces on that side, and the force at the crown.

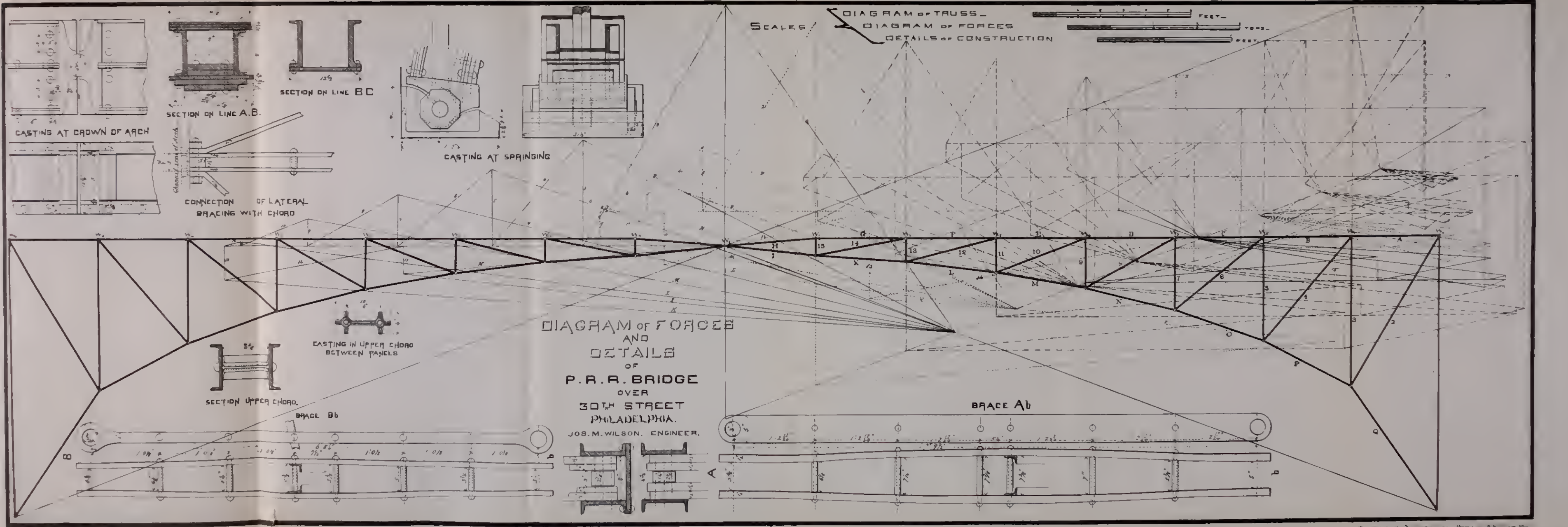
The strains on this particular side of the arch, resulting from the action of the forces on the other side, are all sub-multiples of the strains from the force at the crown, the reactions from this abutment all passing through the crown and springing in the same line, and being proportional to each other as the horizontal distances of the forces from the other abutments. We may therefore compute them from the results of the force at the crown.

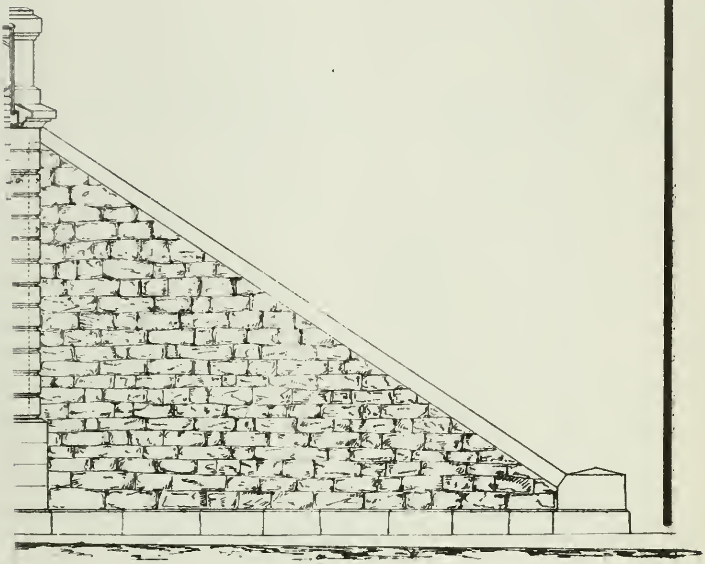
The algebraic sum of the strains, as noted in the table, for any particular member gives the strain on that member for the total load. A portion of the load being variable however, the strain so given may not be a maximum. To determine the maximum strain for any member under the action of any condition of the variable

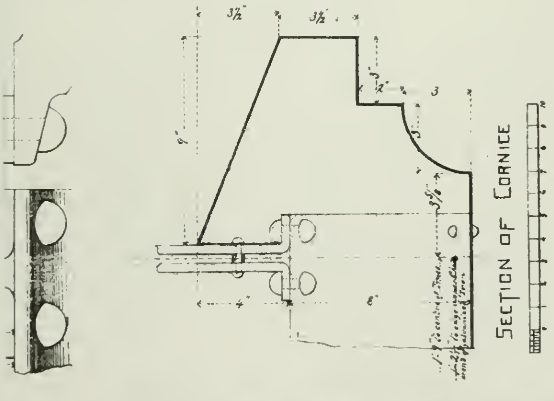
TABLE OF STRAINS.

Members.	TOTAL LOADS.																					Maximum Strains under all conditions of Load.	
	W 0. Tons. 2	W 1. Tons. 4	W 2. Tons. 4	W 3. Tons. 4	W 4. Tons. 4	W 5. Tons. 4	W 6. Tons. 4	W 7. Tons. 4	W 8. Tons. 4	W 9. Tons. 4	W 10. Tons. 4	W 11. Tons. 4	W 12. Tons. 4	W 13. Tons. 4	W 14 Tons. 4	W 15. Tons. 4	W 16. Tons. 2	Sum of + Strains.	Sum of — Strains.	Strains due to Total load Uniform.	+ Strains diminished ¾	— Strains diminished ¾	Comp.	Ten. —
1	+2·00	+2·80	+1·62	+0·44	—0·76	—1·96	—3·14	—4·33	—5·49	—4·80	—4·12	—3·43	—2·75	—2·06	—1·37	—0·69	0·	+6·86	—34·90	—28·04	+1·71	—8·72	....	33·19
2	0·	—3·26	—1·88	—0·51	+0·87	+2·27	+3·66	+5·03	+6·39	+5·57	+4·79	+3·99	+3·19	+2·39	+1·60	+0·80	0·	+40·55	—5·65	+34·90	+10·14	—1·41	39·14	....
3	0·	+4·27	+3·31	+2·36	+1·39	+0·43	—0·53	—1·49	—2·42	—2·12	—1·82	—1·52	—1·22	—0·90	—0·60	—0·30	0·	+11·76	—12·92	—1·16	+2·94	—3·23	8·53	9·98
4	0·	—0·36	—4·36	—3·12	—1·83	—0·55	+0·72	+1·96	+3·21	+2·81	+2·42	+2·01	+1·61	+1·21	+0·80	+0·41	0·	+17·16	—10·22	+6·94	+4·29	—2·55	14·61	5·93
5	0·	+0·20	+4·38	+3·36	+2·32	+1·29	+0·25	—0·75	—1·76	—1·54	—1·32	—1·10	—0·88	—0·65	—0·44	—0·22	0·	+11·80	—8·66	+3·14	+2·95	—2·16	9·64	5·71
6	0·	—0·31	—0·60	—5·31	—3·67	—2·04	—0·41	+1·20	+2·79	+2·44	+2·09	+1·75	+1·39	+1·05	+0·70	+0·35	0·	+13·76	—12·34	+1·42	+3·44	—3·08	10·68	8·90
7	0·	+0·14	+0·24	+4·35	+3·23	+2·11	+1·00	—0·08	—1·16	—1·02	—0·87	—0·73	—0·58	—0·44	—0·29	—0·15	0·	+11·07	—5·32	+5·75	+2·77	—1·33	9·74	2·55
8	0·	—0·25	—0·46	—0·71	—6·61	—4·35	—2·04	+0·18	+2·38	+2·08	+1·79	+1·49	+1·20	+0·89	+0·59	+0·30	0·	+10·99	—14·42	—3·52	+2·72	—3·60	7·30	11·70
9	0·	+0·06	+0·09	+0·15	+4·18	+2·96	+1·76	+0·56	—0·62	—0·55	—0·47	—0·29	—0·31	—0·24	—0·16	—0·07	0·	+9·76	—2·71	+7·05	+2·44	—0·68	9·08	0·27
10	0·	—0·16	—0·27	—0·41	—0·54	—8·36	—4·91	—1·57	+1·72	+1·50	+1·29	+1·08	+0·86	+0·64	+0·43	+0·22	0·	+7·74	—16·22	—8·48	+1·94	—4·05	3·69	14·28
11	0·	—0·03	—0·05	—0·06	—0·09	+3·88	+2·54	+1·22	—0·08	—0·07	—0·06	—0·05	—0·04	—0·03	—0·02	—0·01	0·	+7·64	—0·59	+7·05	+1·91	—0·15	7·49	....
12	0·	+0·11	+0·17	+0·28	+0·37	+0·50	—10·21	—4·87	+0·37	+0·33	+0·28	+0·24	+0·19	+0·15	+0·09	+0·05	0·	+3·13	—15·08	—11·95	+0·78	—3·77	....	14.30
13	0·	—0·14	—0·26	—0·37	—0·50	—0·66	+3·22	+2·01	+0·78	+0·68	+0·58	+0·49	+0·40	+0·29	+0·20	+0·09	0·	+8·74	—1·93	+6·81	+2·18	—0·48	8·26	....
14	0·	+0·72	+1·39	+2·04	+2·71	+3·47	+4·14	—10·96	—4·24	—3·71	—3·18	—2·65	—2·12	—1·59	—1·06	—0·53	0·	+14·47	—30·04	—15·57	+3·62	—7·51	6·96	26·42
15	0·	—0·15	—0·28	—0·42	—0·56	—0·72	—0·85	+3·05	+0·63	+0·55	+0·48	+0·40	+0·32	+0·24	+0·16	+0·08	0·	+5·91	—2·98	+2·93	+1·48	—0·74	5·17	1·50
A	0·	+1·70	+0·97	+0·26	—0·45	—1·15	—1·88	—2·59	—3·24	—2·84	—2·43	—2·03	—1·62	—1·74	—0·81	—0·41	0·	+2·93	—21·19	—18·26	+0·73	—5·30	....	20·46
B	0·	+1·91	+3·80	+2·30	+0·75	—0·79	—2·35	—3·87	—5·35	—4·68	—4·00	—3·34	—2·67	—2·01	—1·34	—0·67	0·	+8·76	—31·07	—22·31	+2·19	—7·77	0·99	28·88
C	0·	+2·14	+4·26	+6·42	+3·60	+0·79	—2·04	—4·79	—7·50	—6·56	—5·63	—4·69	—3·75	—2·81	—1·87	—0·94	0·	+17·21	—40·58	—23·37	+4·30	—10·14	7·07	36·28
D	0·	+2·36	+4·66	+7·02	+9·33	+4·58	—0·25	—4·94	—9·59	—8·39	—7·20	—5·99	—4·79	—3·60	—2·40	—1·20	0·	+27·95	—48·35	—20·40	+6·99	—12·09	15·86	41·36
E	0·	+2·51	+4·92	+7·39	+9·83	+12·37	+4·33	—3·46	—11·21	—9·81	—8·48	—7·01	—5·61	—4·24	—2·81	—1·40	0·	+41·35	—54·03	—12·68	+10·34	—13·51	27·84	43·69
F	0·	+2·38	+4·76	+7·11	+9·59	+11·89	+14·24	+1·22	—11·55	—10·11	—8·66	—7·22	—5·78	—4·34	—2·89	—1·45	0·	+51·10	—52·00	—0·90	+12·77	—13·00	38·10	39·23
G	0·	+1·68	+3·40	+5·11	+6·81	+8·54	+10·17	+12·00	—7·38	—6·46	—5·54	—4·62	—3·69	—2·77	—1·85	—0·93	0·	+47·71	—33·24	+14·47	+11·93	—8·31	39·40	21·31
H	0·	+1·70	+3·42	+5·14	+6·83	+8·52	+10·20	+12·04	—7·43	—6·50	—5·59	—4·64	—3·71	—2·79	—1·86	—0·93	0·	+47·85	—33·45	+14·40	+11·96	—8·36	39·49	21·49
I	0·	—1·04	—2·09	—3·15	—4·18	—5·20	—6·25	—7·43	+12·74	+11·15	+9·56	+7·97	+6·38	+4·77	+3·18	+1·59	0·	+57·34	—29·34	+28·00	+14·33	—7·33	50·01	15·01
K	0·	—1·73	—3·44	—5·14	—6·85	—8·61	—10·31	+3·40	+16·89	+14·78	+12·66	+10·56	+8·44	+6·33	+4·22	+2·11	0·	+79·39	—36·08	+43·31	+19·85	—9·02	70·37	16·23
L	0·	—1·86	—3·62	—5·46	—7·27	—9·13	—0·40	+8·16	+16·61	+14·56	+12·46	+10·38	+8·31	+6·17	+4·15	+2·08	0·	+82·88	—27·74	+55·14	+20·72	—6·93	75·95	7·02
M	0·	—1·75	—3·39	—5·12	—6·80	—1·28	+4·27	+9·71	+15·11	+13·22	+11·34	+9·44	+7·56	+5·67	+3·78	+1·89	0·	+81·99	—18·34	+63·65	+20·50	—4·58	77·41	....
N	0·	—1·55	—3·03	—4·56	—0·97	+2·60	+6·18	+9·70	+13·17	+11·52	+9·88	+8·23	+6·58	+4·94	+3·30	+1·64	0·	+77·74	—10·09	+67·65	+19·44	—2·52	75·22	....
O	0·	—1·35	—2·62	—0·32	+2·02	+4·36	+6·70	+9·00	+11·27	+9·87	+8·46	+7·05	+5·64	+4·23	+2·82	+1·41	0·	+72·83	—4·29	+68·54	+18·21	—1·07	71·76	....
P	0·	—1·18	+0·41	+1·93	+3·48	+5·03	+6·59	+8·11	+9·60	+8·40	+7·20	+6·00	+4·80	+3·60	+2·40	+1·20	0·	+68·75	—1·18	+67·57	+17·19	—0·29	68·46	....
Q	0·	+1·14	+2·30	+3·44	+4·61	+5·73	+6·90	+8·05	+9·16	+8·02	+6·87	+5·73	+4·59	+3·43	+2·29	+1·14	0·	+73·40	—0·00	+73·40	+18·35	—0·00	73·40	....

P^A R R BRIDGE OVER 30TH STREET PHILADELPHIA



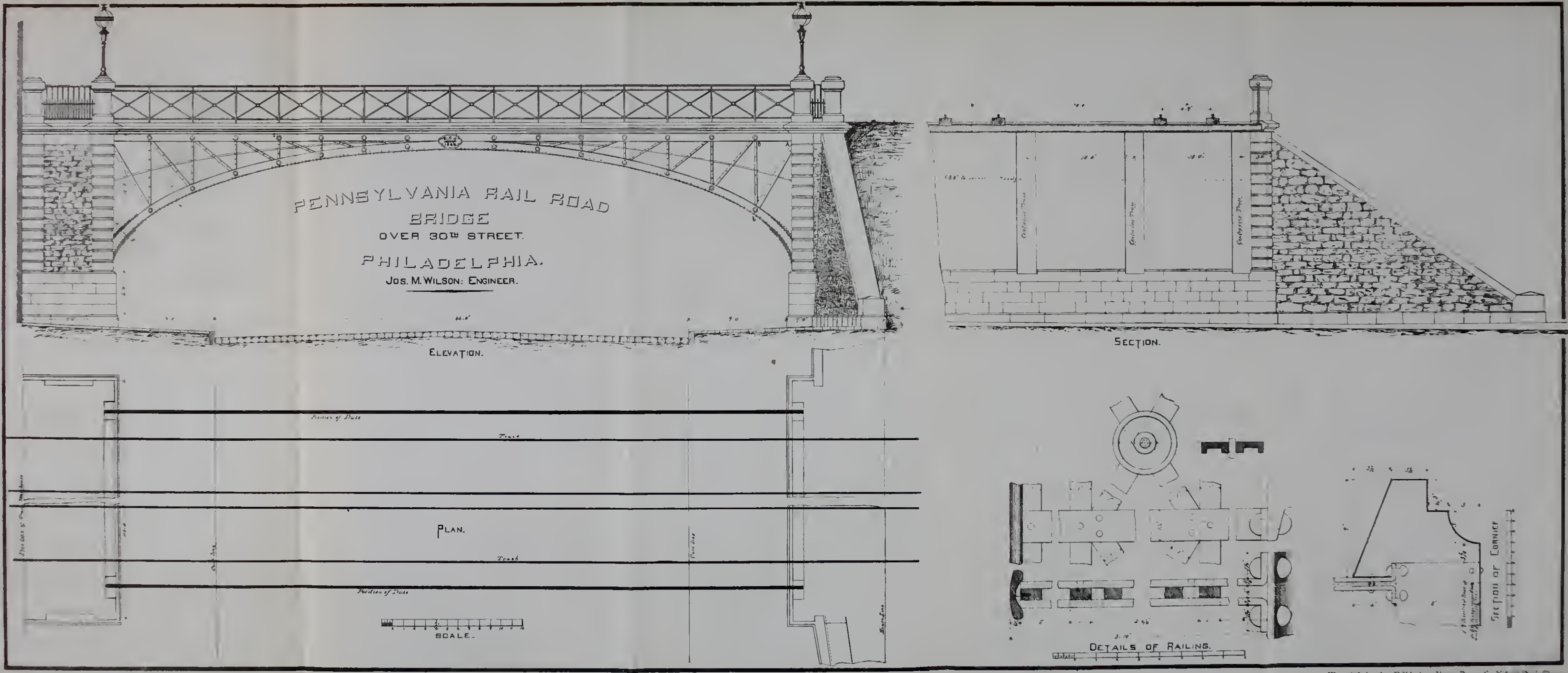




SECTION OF CORNICE

Photolith. by the N.Y. Lithog. Eng. & Printg. Co. 16 & 18 Park Place.

P^{a} R R. BRIDGE OVER 30^{H} STREET PHILADELPHIA



Photolith. by the N.Y. Lithog. Eng. & Printg Co. 16 & [illegible] Park Place load, we notice that three-fourths of the total load represents the variable load. Hence, summing up separately the positive and negative strains as tabulated for the member in question, then adding algebraically the sum of the positive strains to one-fourth the sum of the negative strains, and the sum of the negative strains to one-fourth the sum of the positive strains, the highest results are the maximum strains. Some members have both maximum positive and negative strains under different conditions of the variable load. These members are computed to resist both strains. It may be well to state that the drawings accompanying have been reduced in scale in engraving, and that the diagram of bridge was constructed on a scale of four feet to the inch, and the forces to a scale of one ton to the inch.

The ultimate resistance of wrought-iron for tension was taken at 60·000 lbs. per square inch, and for compression, in the case of short prisms, at 36·000 lbs. per square inch, the computation of sections being made for the various columns according to Rankine's formulæ.

A factor of safety of 6 was used throughout.

The upper chord members, in addition to the strains upon them through the system of the truss, have been computed to resist transverse strain due to load between the points of junction with the braces. It is considered that the stiffening member at centres of braces reduces them to round end columns of half their total length, the effective width of the braces at right angles to the direction of the truss being more than twice that in the direction of the truss. The arch member next to the springing, which has considerable curvature, has been computed to resist the compressive strain to which it is subjected, as a bent column, the additional tendency to flexion owing to its departure from a straight line being taken into account. The connecting pins have been computed, not only for shearing, but also to resist a tendency to pulling or tearing through any of the plates through which they pass, and the pin has always been made of such diameter that its bearing surface upon any such plate or bar does not sustain a greater force than five tons per square inch.

Some tests were made on the Bridge when first opened for use, with an engine and tender, the total weight of which, when loaded, was 115,500 lbs., and the length of bearing on wheels 43 feet. This gave for that length a load of 2,686 lbs. per foot lineal.

Moving the engine slowly on to the bridge, the side on which it came and the crown gradually deflected, while the other side of the arch rose slightly at the haunches. Bringing the engine at rest in centre, the crown gave a deflection of $\frac{5}{8}$ inch, and both haunches rose $\frac{1}{16}$ inch in direction perpendicular to curve of arch. In addition to above deflections, which always recovered themselves after the engine was removed, there was a permanent deflection on first trial of $\frac{1}{8}$ inch.

The actual weights of iron in the structure are as follows:—

With a flat elliptical arch, very little rising at haunches, will allow of considerable deflection at crown, and it is probable that if we had been able to load the whole arch uniformly, the crown deflection would have been less than above noted. Owing to the location of bridge at entrance of Grain Depot we were unable to experiment with high rates of speed. The working of the bridge was in every way satisfactory.

Wrought Iron.

Arch and upper chord members	130,423	lbs.
Braces	45,515	"
Floor beams	104,655	"
Laterals	30,432	"
Pins	12,248	"
Stiffening member for braces	4,139	"
Nuts, bolts, rivets, and ferrules	14,041	"
Railing	2,318	"
	343,821	"
Cast Iron	26,220	"
Total	370,041	"

Indian Coal.—A recent trial of Chanda Coal has taken place by the Great Indian Peninsula Railway officials, at which tw government engineers, who were associated with them in the experiment, reported favorably on the coal in so far, that though it heat-generating capabilities are only half as great as those of english coal, still the difference in cost of the two fuels will give saving to consumers of over 20s. per ton. The coal which wa tested was merely surface coal, and it is fully expected that a muc better description will be obtained at much greater depths.

Mechanics, Physics, and Chemistry.

ELECTRICAL MEASUREMENTS.

On the Atlantic Telegraph Cables of 1865 and 1866. By the Coast Survey expedition of 1866, under DR. B. A. GOULD.

(Continued from page 127.)

ON the 16th of November, I made a series of experiments at Valencia, for the purpose of ascertaining the effect of changes in the electromotive force upon the speed of the signals, and whether these signals could, by the interpolation of any resistance between them and the galvanometer, be made to traverse the double length of the cable before reaching the galvanometer at the same station.

The results of these experiments may be very briefly stated, after mentioning some details regarding the signal-key or commutator. The construction of this key was such, that very little time was lost in pressing down either button, the interval being as nearly as I could estimate, about one-seventieth of a second, or approximately 0s·015. All signals by which currents were sent were given in this way, but the break-circuit signals were given by removing the thumb from the button, which was then lifted by the tension of the spring. This tension being less than the muscular force of the thumb when the button was pressed down, a longer time was consumed in traversing the distance between the stops; and, for this, repeated measurements give 0s·035 as a near approximation to the average interval. Now since, as already related, the ordinary signals record themselves upon the chronograph when the arm carrying the button leaves one stop, but are not really given until it reaches the other, all the recorded intervals between the instants of giving and receiving make-circuit signals will be too large by about 0s·015; while for break-circuit signals the reverse obtains, and the recorded interval will be too small by about 0s·035. Consequently, in comparisons between break-circuit signals and others, a correction must be applied, varying with the temporary adjustment of the signal-key, but amounting on the average at Valencia to not far from 0s·05. The importance of this correction will be recognized on inspection of the results of the first four experiments of the following series. It has, nevertheless, not been applied to any of our results, inasmuch as during the exchanges between Valencia and Newfoundland, no measurements or estimates were made to determine this pass-time for the Newfoundand key. It must, of course, be taken into account in any attempts o draw inferences regarding the relative velocity of break-circuit ignals.

The signals in these experiments were given by Mr. Mosman, and recorded by myself, using the circuit formed by the two cable without any other connections than the same key, galvanomete and battery at Valencia, which had been employed for the othe work of the expedition. Care was of course taken that the signal should be neither seen nor heard by myself, except as indicated by the deflections of the galvanometer-needle.

Exp. I. 4 cells. Circuit made and broken. Key between zincode and galvanometer.

	No.	Mean interval.
Make-circuits	11	0s·257
Break-circuits	11	0·229

Exp. II. 4 cells. The same, with 126 ohms resistance between key and galvanometer.

	No.	Mean interval.
Make-circuits	10	0·279
Break-circuits	9	0·227

Exp. III. 4 cells. Key and galvanometer upon opposite sides of the battery.

	No.	Mean interval.
Make-circuits	13	0·278
Break-circuits	14	0·225

Exp. IV. 4 cells. The same, with 126 ohms resistance between key and cable

	No.	Mean interval.
Make-circuits	11	0·287
Break-circuits	11	0·220

Exp. V. 1 cell. Positive and negative signals.

Positive.		Negative.		Both.	
No.	Mean.	No.	Mean.	No.	Mean.
2	0s·240	8	0s·292	10	0s·282

Here the moments for the positive signals were only recognize with difficulty, 8 out of 10 being lost. The battery-power was insufficient to move the needle promptly, with the existing adjustment of its damping-magnet. The difference in this respect betwee the two classes of signals was very marked, although they alternated at the prescribed intervals of 5 and 10 seconds.

	Positive.		Negative.		Both.	
	No	Mean.	No.	Mean.	No.	Mean.
Exp. VI. 2 cells. Positive and negative signals.	10	0s·249	9	0s·242	19	0s·246
Exp. VII. 4 cells. The same.	8	0 268	10	0 290	18	0 279
Exp. VIII. 10 cells. The same.	10	0·270	10	0·245	20	0·258
Exp. IX. 10 cells. Resistance of 25 ohms interposed between key and ga vanometer.	10	0·254	10	0·258	20	0·256
Exp. X. 10 cells. Resistance increased to 251 ohms.	9	0·287	10	0·289	19	0·288
Exp. XI. 10 cells. Resistance increased to 2513 ohms.	10	0·305	9	0·286	19	0·296
Exp. XII. 10 cells. Resistance increased to 25130 ohms.	11	0·288	10	0·299	21	0·293

From these experiments it may fairly be concluded:—

1. That there was no real difference in the interval for the mak circuit and the break-circuit signals. The mean from the first fo

experiments gives, after application of the corrections for pass-time of the key, an interval 0s·261 for the make-circuits, and 0s·260 for the break-circuits.

2. That the relative positions of key, galvanometer, and battery exerted no perceptible influence upon the result, when a battery of 4 cells was employed. The mean intervals from the first two, and from the second two, experiments are 0s·258 and 0s·262 respectively.

3. That no appreciable effect was produced by the interpolation of 126 ohms resistance. The mean intervals with and without this resistance, were 0s·258 and 0s·263.

4. That no marked diminution of the interval was produced by an increase of the battery from 2 to 10 cells. The results with 1 cell, although untrustworthy, indicate a somewhat less interval. The others vary by less than their probable errors, yet the interval was certainly not greater with 2 cells than with 10.

5. From the last three experiments it would appear that the interval was slightly longer after resistances above 250 ohms had been introduced. Yet it was no longer in the 12th experiment, when the resistance between the key and the galvanometer was more than two-thirds greater than the whole resistance of the two joined cables, than in the 11th when it was only one-sixth as great as that of the two cables.

6. We have every reason for believing that in all these twelve experiments, the measures of the intervals were merely determinations of my own personal equation in noting signals, which, as has been shown in Chapter IX, had been found by special investigation to be about 0s·275. The variations from this value amount n but few cases to more than ± 0s·03, which we have seen to be the normal range.

7. These experiments are entirely confirmatory of what would have been anticipated from theory, viz., that a signal given by closing a galvanic circuit is transmitted in both directions simultaneously, and with equal velocity under similar circumstances; so hat under no ordinarily practicable circumstances could a signal from either station fail to traverse both parts of the circuit at that station before passing on to the other.

Since the investigation* in 1850 to which I have alluded, the progress of science has thrown light upon many points which then were subjects of doubt or of individual opinion. The condition of an open galvanic circuit is now almost universally conceded not to be essentially different from that of an interrupted conductor to an electrical machine. The velocity of a current is also known to be dependent upon its quantity, and therefore generally upon its intensity, as well as upon the resistance of the conductor. But it ppears questionable whether the law is so simple as has been supposed by some, who have regarded the velocity as inversely proportional to the capacity of the conductor multiplied by its resistance, and therefore, in a homogeneous conductor, to the square of its length. For the problem, as it now presents itself, does not pertain so much to the time for transmission of a given signal, as to the time for its transmission with a certain force, depending on the sensitiveness of the receiving apparatus; since the electrical impulse or disturbance consists of a continuous series of molecular influences which propagate themselves in every possible direction according to the inverse ratio of their several resistances. And the form of the conductor, as well as other conditions, may essentially modify the time requisite for the attainment of the prescribed force at the other extremity of the line. A current may thus be temporarily established in part of an open circuit, continuing until the battery and conductors have attained an electrostatic equilibrium. The time required for attaining this equilibrium depends of course simply on the capacity and form of the conductors, and on the energy of the battery; but the first electrical impulse may reach the most remote point of the circuit before a portion nearest the battery has received its full charge. Similarly, in a closed circuit, the distant extremity of the line may well be supposed to perceive some slight electrical disturbance from a signal, before its full force is manifested at intermediate points; so that a signal might be received with a delicate galvanometer at the farther extremity, before it could be recognized upon an electro-magnet at half the distance. And this, too, apart from any consideration of increasing intensity in the electromotor.

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* Proc. Amer. Assoc. Adv. Sci., 1850, p. 71; Am. Jour. Sci. XI, 67, 154.

The circuit formed by the two cables might, although broken at Valencia, thus serve to establish what would practically be a momentary current at Newfoundland when the battery at that station was introduced, deflecting the galvanometer there for an instant; and the change of statical condition in the cables at Valencia would thereupon be manifest to the electroscope. But the closure of circuit at Valencia would be accompanied by instantaneous deflection of the galvanometer, with corresponding insensibility of the electroscope. Thus a signal given by closing or interrupting an insulated circuit at any point is instantaneously transmitted from that point in both directions, and at full speed; but the interval before it attains its total force at any other point, must depend upon the character of the intervening conductor.

The question as to the route by which signals are transmitted, when part of the circuit is formed by the earth, is thus disposed of; and the position maintained in the memoir above cited seems entirely corroborated, although it loses its theoretical significance. Prof. Kuhn, in his learned and valuable *Handbuch der Elektricitäislehre*,* while doing the fullest justice to the former investigation in other respects, takes exception to the propriety of my inferences regarding this question, but careful reconsideration has failed to convince me of any flaw in the argument, such as it is, notwithstanding my distrust of any reasoning from which so eminent a physicist would dissent.

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* Allgemeine Encyklopädie der Physik. Bd. XX, p. 494, Leipzig, 1866.

It is not without hesitation that I present the facts and inferences of this chapter. For I am not unaware of the careful and thorough quantitative investigations of Thomson, Jenkin, and others, and should of course shrink from publishing these relatively crude and very incomplete results, were it to be supposed that I regarded them as comparable with those obtained by those distinguished electricians. But the opportunity of adding some few facts to those heretofore established seemed worth improving, although it was with no special apparatus, and was entirely collateral and subordinate to the astronomical purposes of the expedition. And furthermore, the question has an especial interest for me, as having been among the first to demonstrate and measure nearly twenty years ago the transmission-time of the galvanic signals, which had previously been assumed to be instantaneous. The duration of our signal-currents was intended to be uniformly one-quarter of a second, but depended upon the skill and care of the observer, no automatic signal-giver having been employed. Every electrician knows how greatly the strength of the current is augmented by an increase of its duration from $0^{s}.2$ to $0^{s}.3$; yet the duration of the signals varied frequently through a larger range than this. Still the actual length of each signal is recorded upon the chronograph-register, and its average did not vary much from the prescribed duration of $0^{s}.25$.

It appears manifest that not an electrical charge or discharge, but simply an electrical disturbance, is requisite for transmitting a signal; that an inductive impulse, sufficient to deflect the galvanometers employed, was transmitted through one cable, having at each end a condenser with 10 cells, in somewhat less than the third of a second, five seconds after the transmission of an impulse of the opposite sort; that with a circuit formed by the two cables, a smaller electromotive force sufficed to transmit the signals with yet greater rapidity; that the signals traveled more rapidly through a cable which had not recovered its electrical equilibrium after a current of the opposite character; and that the speed of the signals is modified by the earth-connections, more readily than by changes* in the battery-power. And the very marked differences, found in the rates of transmission, between signals given by completing an interrupted circuit and those given by interrupting a closed circuit, may perhaps lead to investigations which will afford an explanaion.

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* Jenkin (Phil. Trans. CLII, 982) arrived at the conclusion that the electromoive force of the battery has no appreciable effect on the velocity with which the urrent is transmitted. But, he would doubtless consider that some qualifications o the general statement should be taken for granted.

A LABORATORY OF EXPERIMENTAL RESEARCH.

By Prof. Albert R. Leeds.

One of the most important services rendered by the great Swedish Chemist to his beloved science, was, that he freed it from its previously attendant mystery and discomfort, its dirt and gloom. The cold outbuildings and damp stone floors, hitherto thought proper for destructive acids and noxious vapors and dangerous furnace fires, were too unwholesome to be endured through the protracted severities of a Swedish winter, and so Berzelius carried his crucibles into comfortable rooms in his own dwelling, made the clumsy furnace yield to his convenient lamp, and made chemistry a science most cheerful and domestic. Among the young chemists, who were attracted by the splendor of his discoveries to the home of Berzelius, was Henry Rose. When, later in life, Rose became Professor of Chemistry in the University of Berlin, he also devoted two or three small rooms in his own house, and admitted to them a few students, who came highly recommended for their skill and chemical knowledge, to work out analytical methods under his direction. Among them, and for several years his assistant, was Dr. Finkener, recently appointed Professor at the Berg Schule in Berlin. This Berg Schule occupies the Old Bourse, and the chemical laboratory is the large hall in which the bankers of Berlin were wont to assemble before their present magnificent Bourse upon the opposite side of the Spree was erected. The assiduity care and ingenuity which Dr. Finkener has displayed in the last, the sixth, and in former editions of Rose's great work on Analytical Chemistry, has given him a familiarity with analytical processes which has rendered him deservedly successful and popular as a teacher. To an American the fees in the institution appear incredibly small. For the daily use of the laboratory for five months, including gas chemicals and apparatus, the charge is twenty thalers, about twenty dollars in currency at the present time, Nor is this economy obtained at the sacrifice of those facilities which the student may reasonably expect in the present advanced state of chemical science. One or two agate mortars, a couple of steel mortars, the cork-borers, files and other simple tools, the sand and water baths, etc., are the property and for the use of all. The students enforce the police regulations, and keep the laboratory in order.

The apparatus for the evolution of sulphuretted hydrogen, carbonic acid and hydrogen is arranged by an assistant, and the time of the student is not consumed in preparing these contrivances for himself. The same remark applies to the apparatus for the manufacture of chlorine, hydrofluoric acid, the determination of carbonic acid, nitrogen, etc., to the burettes and standard solutions for volumetric analysis. In desk-room the student is limited, though not hampered, for want of space; of hood-room there is more than sufficient for all the evaporations and operations detrimental to health, which the students are likely at any one time to be carrying on. How different from one of the largest of our American laboratories, where the regular charges are $100 per term and the incidental amount to a very considerable sum. Each student is required to consume time and money in constructing a sulphuretted hydrogen, carbonic, hydrogen, and other apparatus for himself, and without he consumes more of both than most can afford, his apparatus, when completed, is inadequate to accomplish nice work or obtain accurate results. In respect to size and completeness the laboratory of the Berg Schule, at Berlin, is much superior to that of the Mining School at Freiburg, now, and for many years past, under the direction of Professor Scheerer. The rooms are small, dark and ill provided with gas and apparatus.

Since the calamities which have fallen upon the kingdom of Saxony, the places of such as Breithaupt, and his illustrious colaborers, have not been filled by men of equal renown, and the ancient glory of the institution is departing. The student still goes to see the great cabinet of minerals accumulated by the father of geology and his successor, and still may obtain excellent practical instruction in the determination of minerals. Here, as at some other places in Europe and in our own country, where mineralogy is successfully taught, fragments of crystals are put into the hands of students and they are expected, under the eye of the teacher, to determine their hardness, cleavage and crystalline form. Their attention is directed to the peculiarities of surface condition, optical properties, etc., and they are taught to substitute critical examination for slovenly guess work. The fiery enthusiasm with which the old professor of metallurgy performs his duties, still attracts students, who have finished their studies at other schools, to Freiburg for this special course, and nothing, certainly, can be more gratifying than the zeal with which the lynx eyes of the Professor follow the assay from the incipient stages of its preparation, through the blazing furnace, to the triumphant moment when the button emerges into view. The metallurgical apartment at the Ecole des Mines in Paris is more imposing in appearance; with its practical working I am not so well acquainted. The free laboratory in the Jardin des Plantes is adapted only to elementary work; that at the Ecole Centrale is dirty and dismal, and that of the Sorbonne, which was erected at about the same time as the great Frederick Wilhelm Laboratories at Bonn and Berlin, is not comparable to either in size, elegance and completeness. In the latter of these two noble edifices, the beautiful lecture-room is provided with a special laboratory for the preparation of lecture experiments, and also a museum of such minerals, apparatus, models and metallurgical and industrial products, as are useful in demonstration or illustration. Between the spacious apartments for qualitative and quantitative analysis, there is a room devoted to the preparation of reagents. There are also separate apartments set aside for metallurgic and pharmaceutical processes, weighing rooms, a library, a room for organic analysis, and one for students engaged in original investigation.

There is no provision, however, for the prosecution of researches in Physics, and but scanty accommodations to workers in Physiology. Prof. Magnus, of the University of Berlin, has devoted a few rooms in his dwelling to physical research, and while I was engaged there, three other students were present, one occupied by an investigation in Acoustics, another in Polarised Light, and a third in the measurement of crystals of recently discovered chemical compounds. A Laboratory of Physics is greatly needed at the present time in our own country. The teachers of Natural Philosophy in our colleges have little opportunity for fitting themselves, by a course of special training for their duties, and are seldom able to make or improve their apparatus, or to enter with success into experimental research. A chemist is able to effect little who has not acquired, by years of practice, skill in the conduct of analyses. So too, other things being equal, he will be the most successful physicist, who is the best mechanician. In such an institution the mechanical ought to advance with the mathematical education, and while the pupil is studying mensuration he might be mastering the turning lathe; and while applying calculus to optics, in grinding and mounting a lens. We do not advocate such an education only for those who design to be Physicists by profession, but regard it as best adapted to develop many minds, and to bring forth a kind of talent eminently useful. Where shall the Civil Engineer, the Miner or the Architect, get such an education at present? Yet, to all these men, the ability to construct as well as to plan a house, machine or engine would be of inestimable value. Moreover a long course of theoretical instruction alone is dry, and oftentimes disheartening, especially to those who with great native ingenuity and mechanical skill have little facility in mathematics. Such a Physical Laboratory should have a carpenter shop with tools for all kinds of joinery and turning, a machine room with furnace, bellows, anvils, vices, lathes, etc., and a room for finishing apparatus, and the nicer kinds of work. Under the conduct of skilled mechanics, the students might be taught to make the apparatus requisite to demonstrate the principles of Natural Philosophy, and when they were prepared to undertake researches of their own, or to take their degrees as engineers, they would be able to cope with the practical matters which would occupy their time and energies. Besides the work-shops, there should be separate rooms in a laboratory of this description, devoted to researches in Heat and Optics, including Spectrum Analysis, Photometry, Microscopsy and Crystallography, to Acoustics, Electricity and Magnetism, and to the problems of Engineering. We believe that there are many young men to whom an education of this kind would prove more attractive than any now obtainable, and that the practicable benefits as well as the scientific results of such an institution would be very great.

A PROCESS FOR QUICKLY AND ACCURATELY DETERMINING THE AMOUMT OF CHROMIUM AND IRON IN CHROME IRON ORES.

By J. Blodget Britton, of the Iron Masters' Laboratory.

Reduce the mineral to the finest state of division possible, in an agate mortar. Weigh off ·5 grm. and add to it 4· grms. of a flux, previously prepared, composed of one part chlorate potassa and three parts soda-lime; thoroughly mix the mass by triturating in a porcelain mortar; and then ignite in a covered platinum crucible at a bright-red heat for an hour and a half or more. The mass will not fuse, but when cold can be turned out of the crucible by a few gentle taps, leaving the interior of the vessel clean and bright. Triturate in the mortar again and turn the powder into a tall 4 oz.

beaker and add about 18 c.c. of hot water, and boil for two or three minutes; when cold, add 15 c.c. of hydrchloric acid of common strength, and stir with a glass rod for a few minutes, till the solid matter, with the exception, probably, of a little silica in a flaky gelatinous state, becomes dissolved. Both the iron and chromium will then be in the highest state of oxidation—$Fe_2\,O_3$ and $Cr\,O_3$. Pour the fluid into a white porcelain dish of about 20 oz. capacity, and dilute with washings of the beaker to about 3 oz. Immediately after, also, pour cautiously into the dish 1· grm. of metallic iron of known purity, previously dissolved in dilute sulphuric acid and further diluted with *cold* water to about 5 oz., to make up the volume in the dish to about 8 oz. (I use for the purpose fresh borings from a piece of bar iron, containing less than ·05 of foreign matter, dissolved in 18 c. c. of dilute sulphuric acid of 1 pt. acid and 3½ pts. water, in a tube 12 inches long and ⅞th inch diameter, closed at the top with a gum stopper perforated for a ¼th inch tube, bent short round at right-angles and extending horizontally about 3 or 4 inches, applying heat to expel atmospheric air and facilitate operations. When the iron is dissolved, and having tested the solution for sesquioxide, I nearly fill the tube with *cold* water and cautiously pour the contents into the dish and add about 2 tubes-full more of *cold* water to make up the solution to about 8 oz.,) and then determine, volumetrically, with a standard solution of permanganate of potash, the amount of protoxide of iron remaining. The difference between the amount of iron found and of the iron weighed will be the amount oxidized to sesquioxide by the chromic acid. Every one part so oxidized will represent ·320 of metallic chromium, or ·4663 of sesquioxide, $Cr_2\,O_3$, in which last condition the substance usually exists in the ore.

If the amount of iron only in the ore is to be determined, the process is still shorter. After the fluxed mineral has been ignited and reduced to powder, as already directed, dissolve it in a tube of the kind described, by adding, first, 10 c.c. of hot water and applying a gentle heat, and then 15 c.c. of hydrochloric acid, continuing the heat to incipient boiling till complete decomposition has been effected; cool by immersing the tube in a bath of cold water, add pieces of pure metallic zinc (sheet zinc cut in small strips I prefer) sufficient to bring the iron to the condition of protoxide and the chromium to sesquioxide, and apply heat till small bubbles of hydrogen cease, and the zinc has become quite dissolved; then nearly fill the tube with *cold* water, acidulated with $\frac{1}{10}$th of sulphuric acid, and pour the contents into the porcelain dish, add *cold* water to make up the volume to about 8 oz., and complete the operation with the standard permanganate solution.

The process, if conducted as directed, affords very accurate results; upon repeating the determinations there should be practically no variation. The whole time consumed need not exceed three hours to determine both the chromium and the iron, if the two ignitions are proceeded with simultaneously.

It need scarcely be remarked that fine iron wire or ammonio-protosulphate of iron may, in most cases, be used with greater convenience than borings. I, however, in my own practice, prefer the latter, and for several years past have kept in the laboratory for use a large piece of iron of the kind mentioned, from which, by the aid of a small foot-lathe, I obtain in a moment or two clean unoxidized borings whenever they are needed, and thus have an unalterable standard always at hand.

For dissolving minerals and metals, I constantly use tubes of the kind described, though sometimes of a larger size, prefering them generally to all other vessels for many reasons :—avoidance of loss of substance, convenience of rinsing, expulsion of air while digesting and boiling, carrying out of the laboratory all of the evolved gases by means of the small bent tubes leading into a chamber connected with the main chimney, &c.

When determining iron volumetrically with the permanganate solution, I also always use the cold water acidulated with sulphuric acid, when hydrochloric acid has been the solvent, because with it the final relation is more distinct and the results more constant, besides, if previously prepared in quantity, and cold, it at once reduces the temperature of the hot fluid, and so saves time.

Important Guano Discovery.—An important phosphatic deposit has recently been found near St. Petersburg, on the southern coast of the Gulf of Finland, in Russia. It is probably similar to that recently found near Charleston, S. C., but of much less extent. It was discovered by some laborers while draining a piece of low land, at a depth of about 6 feet from the surface. It is situated in the midst of an agricultural district, where mineral manures are much needed

THE NASCENT STATE.

By M. H. Sainte-Claire Deville.

(Translated for the Journal of the Franklin Institute.)

(Concluded from page 144.)

In this kind of explanation which does not require any hypothesis of a new and unknown state of matter, ammonia should proceed from the elements of bihydrated nitric acid, the nitrite of ammonia ($Az\ O_2\ H_2$) and the nitrate of ammonia ($Az\ O^3\ H^2$) being considered as two terms of deoxydation of nitric acid to 2 equivalents of water ($Az\ O\ H_2$.)

Nitrogen and the protoxide of nitrogen may also proceed from a disconnected and incomplete decomposition of the nitrite and nitrate of ammonia, which are so unstable in their nature.* I have had reason to explain how the diffusion of salts in water (see the lessons before the Chemical Society (1866 Hachette) on disconnection, commencing on page 269) can promote disconnection. Graham's great works on diffusion and dialysis are a manifest proof of this. M. Marignacs last experiments also leads to the same conclusion.

All these phenomena come under the head of those which are well known and which can be explained without any especial hypothesis.

It is only necessary to show now in what proportion ammonia and the protoxide of nitrogen, nitrogen and nitrous acid are produced in a liquid where the composition, the temperature and the tension of the solution of gases are unknown. I have made a great many determinations of this kind (the results of which are too numerous to mention in this memoire) by means of a very complicated apparatus which will be described in a more detailed memoire. I treated zinc successively with 1000 grammes of water containing 2, 4, 6, 20 grms. of anhydrous nitric acid. I here give a table of the first and last experiments where I carried the quantities of the solution of zinc to the equivalent 33 and in which I determined the quantities of zinc that each of the elements found in the liquid had transformed into oxide.

My experiments prove that the quantity ammonia, the quantity of zinc, of which this, in forming, has promoted the oxydation and the quantity of anhydrous nitric acid which supplied nitrogen does

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* Above all when in a current of gas (see the experiments of M. Gerney.)

	Anhydrous Acid........2. Water... 1,000			Anhydrous Acid.......20. Water................1,000.		
	Quantities Produced.	Zinc Oxydized.	Acid Consumed.	Quantities Produced.	Zinc Oxydized	Acid Consumed.
Ammonia.....................	0 825	12·81	2·62	0·826	12·83	2·62
Nitrogen........	1 004	11·83	3 87	0·	0·	0·
Prot. of Nitrogen..........	0·	0·	0·	1·888	11·33	4·64
Nitrous Acid................	4·813	8·36	6·84	5·095	8 84	7·23
		33·00	13 33		33·00	14·49

not vary much when the strength of the acid solution varies. The quantity of nitrogen decreases and the quantity of protoxide increases when the concentration of the liquid is augmented.

In my next communication I will show the results of a number of experiments on the relative numerical determinations of the action of zinc and other metals on the mixture of nitric with sulphuric acids and the hydrogen acids.

Lead-poison from Warm Water Pipes.—In the English *Chemical News* for November 26th, we find the following in the report of remarks made by Dr. Wallace, in the Chemical section of the Glasgow Philosophical Society.

"A new and very different source of danger, however, was revealed by the analyses" (of water taken from cisterns in various parts of Glasgow.) "It was found that water which had got warm by remaining in pipes which were exposed to warmth, either by proximity to the usual hot water pipes or otherwise, was frequently contaminated with lead to such an extent as to render the use of the water for dietetic purposes positively dangerous."

Commercial Nickel, so says M. Raoult, will occlude 165 times its volume of hydrogen gas. He seems to regard it as a simple absorption such as happens with charcoal; for it appears that once hammered, the metal loses its porosity and power of absorption.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, January 16th, 1870.

The meeting was called to order, with Prof. R. E. Rogers, Vice-President, in the chair.

The minutes of the last meeting were read and approved, and the minutes of the Board of Managers, including the annual report of the President, Mr. J. V. Merrick, were submitted by the Actuary, and the following donations were acknowledged:—Institute of Actuaries; Society of Arts, London; Association for the Prevention of Steam Boiler Explosions, Manchester, England; l'Academie des Sciences, la Société d'Encouragement pour l'Industrie National, Paris, France; Natural History Society, Montreal, Canadian Institute, Toronto, Canada; Board of Public Works, Chicago, Illinois; Louisville and Nashville Railroad Company, Louisville, Kentucky; Prof. Fairman Rogers, A. A. Moss, Esq., Philadelphia, Pennsylvania.

The Judges of Election have reported the result of the ballot as follows:—

President.
Coleman Sellers.

Vice-President.
Henry G. Morris.

Treasurer.
Frederick Fraley.

Secretary.
Prof. Henry Morton.

Board of Managers.

(For three years.)

Wm. Sellers,
J. V. Merrick,
Henry Cartwright,
Samuel Hart,
Wm. B. Bement,
Henry W. Bartol,
J. H. Cooper,
Theo. Bergner.

(For two years.)

Wm. P. Tatham,
Dr. Isaac Norris, Jr.

(For one year.)

Dr. R. E. Griffith.

Auditor.—J. H. Cresson.

Mr. Coleman Sellers, the President elect, was then duly installed.

The various committees then reported their minutes, and the Resident Secretary read his report on Novelties in Science and the Mechanic Arts.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA,
FOR THE
PROMOTION OF THE MECHANIC ARTS.

VOL. LIX.] APRIL, 1870. [NO. 4.

EDITORIAL.

ITEMS AND NOVELTIES

Illinois and St. Louis Bridge.—Further particulars since our last issue.

The east pier reached the rock on the 28th of February 95 feet below the surface of the water; and at this date, March 27th, the west pier is within a few inches of the rock. The present heighth of water is 19 feet 6 inches below the city directrix, making the depth of the east pier 100 feet and 6 inches and the west pier nearly 72 feet.

At a depth of 85 feet it was first noticed in the east air chamber that the flame of a candle would immediately return when blown out by the breath, some times after an interval of a few seconds; and that repeated blasts of the breath were required to finally extinguish the light. This phenomenon is not observable at the present depth of the west air chamber (over 71 feet.) The flame of the candle is perhaps twice as large as in the normal atmosphere, but such large quantities of carbon (particles of lamp black) and smoke are emitted as to constitute a serious annoyance, requiring several expedients to get rid of it. Two curious accidents, from fire, have occurred in the east chamber, one of which caused serious injury to one of the workmen. This man was engaged in passing out cement from the air-lock into the air chamber when his coat skirts came in contact with a candle in the lock, and although his garments were *woolen*, one leg and arm were badly burned before the flames could be extinguished. In the other case the under clothes of the man saved him from injury, the external ones about the waist being badly burned, and only extinguished by his fellow workmen throwing him down into a pool of water in the bottom of the chamber. Candles are the only lights permitted within the air chambers, being least liable to cause accidents. About 4 atmospheres are now contained within the east air chamber, the pressure being about 44 pounds above the normal one.

Within the last few days several of the workmen employed in filling the east chamber with concrete have been severely attacked with paralysis. No death from this cause occurred until after the depth worked in was over 95 feet. 3 or 4 have occurred within the past ten days which were believed to have been superinduced by the severe air pressure. At the coroner's inquest, held on the last one, two distinguished physicians present attributed the abnormal developments exhibited by *post morten* examination to diametrically different causes. One to a too sudden change from the normal to the dense atmosphere; and the other to the too rapid transition from the dense to the normal pressure. Neither of these are correct, as the lock-tenders have never been thus affected, while they are alternately under the pressure 15 to 20 times during a watch of 2 hours while passing the workmen in and out. It is probable that the duration of time to which the system is subjected to the unnatural pressure is the chief cause of the paralysis induced, as many hundreds, indeed thousands, of visitors have entered and remained in the chamber from 30 minutes to an hour and a-half, without one of them being thus affected. The Chief Engineer forbade the workmen remaining longer than one hour at a time in it. After thus working for four days, the workmen themselves protested and petitioned against this, and two hour shifts have been since instituted in consequence of their expressed desire.

The filling of the east chamber is progressing satisfactorily and is about half complete.

The Tehuantepec Canal Scheme vs. The Darien and Nicaragua Routes.—Mr. Fenton submitted the other day, in the United States Senate, the following resolution, which awaits the action of that body :—

Whereas the commerce of the world, and more especially that of the Western hemisphere renders it important that a ship canal should be constructed across the American Isthmus ; and whereas the government of the republic of Mexico has conceded to an American company the privilege of opening interoceanic communication by means of a railway across the Isthmus of Tehuantepec, and now proposes to add thereto a concession for a ship canal, therefore be it

Resolved, That if the President of the United States shall obtain the assent of the government of Mexico, then the Secretary of War is hereby authorized to detail a corps of engineers to make a survey of the summit of the Isthmus of Tehuantepec, to ascertain if there be sufficient water at the summit of said Isthmus for a ship canal; and, if it should be found on examination that there is sufficient water, then a survey of the Isthmus for a ship canal shall be made, from the Gulf of Mexico to the Pacific Ocean, together with the complete plans, profiles and estimates for the same, under such regulations and with such provisions as the committee on foreign relations may recommend.

This resolution, we presume, has been offered on the application of the company concerned. We apprehend, however, that no corps of engineers will be necessary to establish these two points—first, that on the summit level of the Tehuantepec route there is not sufficient water to supply a ship canal, and second, that, even with sufficient water, the length—nearly two hundred miles—of said canal, and the costs of construction and the lockages of the route, would render the scheme impracticable. If we are not mistaken these conclusions were reached by President Buchanan after a careful examination of the difficulties of the route for the purposes of a canal. For our part, of all the proposed American Isthmus routes for a ship canal, this of Tehuantepec seems the most impracticable and visionary.

We entertain a hope that the United States surveying expedition recently sent out from this port to explore the Isthmus of Darien, in order to find out whether in that quarter there is or is not a short and feasible route for a ship canal between the two oceans, will discover the very route desired. Should the explorations of this expedition, however, result in establishing the fact that there is no practicable route across the Darien Isthmus for a ship canal without expensive locks or tunnels, then the favorite route of Louis Napoleon—the Nicaragua route—will, we have no doubt, be the route adopted.

We have before us a handsomely printed and illustrated London book, issued in 1863, and entitled "The Gate of the Pacific," by Commander Bedford Pym, R. N., in which we find a very interesting chapter devoted to the project of a Nicaragua ship canal. Commander Pym prefers this route as the Pacific gate for a railroad, but he also makes a strong case for it in favor of a canal. The reader, in turning to the map of Nicaragua, will observe that the continent here in a direct line is not much over a hundred miles wide, but that by the line proposed the canal will be nearly two hundred miles in length, from sea to sea. He will observe, however, that the proposed line is that of the San Juan river (a navigable stream for small steamboats most of the way) and through Lake Nicaragua (fully half the size of Lake Ontario) and thence by a canal of some fifteen or eighteen miles to San Juan del Sur, on the Pacific, or the canal from Lake Nicaragua may be continued northward up the connecting river to Lake Monagua (another fine body of fresh water) and thence across to Port Raelejo, on the Pacific. In a pamphlet written in 1847 Louis Napoleon says of a ship canal by this route, and referring to Massaya, a thrifty town between Lake Nicaragua and Monagua, that "as Constantinople is the centre of the ancient world, so is the town of Leon, or rather Massaya, the centre of the new, and if the tongue of land which separates its two lakes from the Pacific Ocean (fifteen miles) were cut through she would command, by her central position, the entire coasts of North and South America. * * * The state of Nicaragua can become, better than Constantinople, the necessary route for the great commerce of the world; For it is to the United States the shortest route to China, and for England and the rest of Europe to New Holland, Australia, Polynesia and the whole western coast of America."

This is Louis Napoleon's opinion. This canal, too, from the Atlantic side to Lake Nicaragua can be made by dams and locks in the San Juan river. Commander Pym estimates the cost of the canal from sea to sea, including a regular canal along the bank of the San Juan up to the lake, at four million five hundred thousand pounds, or say twenty two million five hundred thousand dollars. Commander Vanderbilt has proved on this Nicaragua route that with only the fifteen miles from Lake Nicaragua or Monagua to the Pacific cut through with a ship canal, Louis Napoleon's opinion of this route would soon be confirmed.

We say, then, that should it appear that there is across the Darien Isthmus no available route for a ship canal, the Nicaragua route will be the route adopted, and in the saving of six or seven hundred miles over the Darien route this shorter line, in any event will perhaps be the ultimate route for the United States.

Titanic Iron.—Ilmenite, or titaniferous iron, has been mined more or less in Norway for some time, and brought to England for fettling puddling furnaces, for which purpose it is especially adapted. But this did not pay, and as chemists have failed to smelt it, except at too great cost, the mines were given up. Recently attempts were made to make bricks with this ore in combination with fire-clay, for the purpose of lining furnaces. Some of the prepared bricks were placed on the bridge of a furnace to try them; but as soon as the ingredients of the clay were reduced the bricks disappeared. Here was a clue to the flux required; and now the ore is regularly smelted, producing a remarkably fine kind of iron, superior even to Swedish.

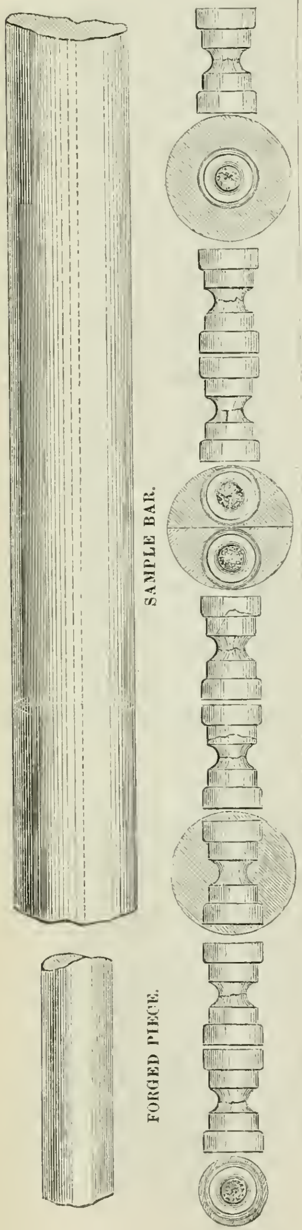
Experimental Test of Bar Iron.—By William H. Shock, C. E., U. S. N.—I was called upon to examine and test some samples of rolled bar iron furnished to the government, under contract.

In the lot submitted, there was a sample cut from a four (4) inch bar, from which twenty-eight (28) specimens were prepared, under seven (7) different conditions, as will be seen by the annexed drawings. As was to be expected No. 4 series gave the highest results, having been reworked on the anvil.

These experiments develop the absence of homogeneousness in rolled bars, and imperfect welding, as shown by some of the experiments in No. 4 series. The average tensile strength of the iron may be considered good, nevertheless.

TABULAR EXPOSITION OF EXPERIMENTAL TEST MADE WITH ROLLED BAR IRON

SKETCH OF SPECIMEN AND SAMPLE BAR.



Diameter in inches.	Area in square inches.	Breaking Weight in pounds.	Mean Tensile Strength in pounds.	Average Breaking Weight in pounds.
Specimens cut from Centre of Sample Bar.				
·805	·5089	24,250	47651·7	59294·5 No. 1.
·805	·5089	34,800	68382·7	
·805	·5089	30,550	60031·4	
·805	·5089	31,100	61112·2	
Specimens cut from Sides of Sample Bar.				
·800	·5026	27,525	54765·2	59087·2 No. 2.
·805	·5089	31,000	60915·5	
·810	·5153	31,650	61420·5	
·805	·5089	23,150	59245·4	
·800	·5026	30,250	60187·0	
·805	·5089	29.850	58655·9	
·805	·5089	28,000	55020·6	
·805	·5089	31,000	62487·7	
Specimens cut across Sample Bar.				
·805	·5089	20,000	39300·4	53163·0 No. 3.
1·407	1·4097	16,000	11349·9	
·805	·5089	19,175	37679·3	
·805	·5089	17,375	34242·2	
·810	·5153	21,000	40752·9	
1·413	1·5681	17,000	10834·1	
·810	·5153	20.650	40073·7	
·810	·5153	20,000	38812·3	
Specimens forged from Sample Bar.				
·805	·5089	30,750	60424·4	60565·3 No. 4
·795	·4963	32.200	64880·0	
·805	·5089	26,275	61630·9	
·810	.5153	32,300	62681·9	
·810	·5153	31,550	61226·4	
·810	·5153	29,000	56277·8	
·810	·5153	33.250	64525·5	
·810	·5153	32,400	62875·9	

East River Bridge.—This huge work is fairly under way, and its progress is looked upon with an intense interest by the public at large. All the energy of the company is concentrated, for the present, on the foundations for the eastern abutment, during the course of which some interesting experiences are to be noticed. A rather novel and highly successful mode of submarine blasting has been adopted, and I am indebted to Mr. Collingwood, Assistant Engineer, for the following particulars. In preparing the river bottom for the reception of the "caisson," there developed, shortly after the dredges were put to work, an exceedingly hard ridge of material through the centre of the proposed excavation. This ridge was composed of boulders of all sizes, imbedded in a compact clay. On this the dredges could make no impression, and it was determined to try blasting in the following manner: A solid bar 18 feet long and 5 inches in diameter was shod with a steel point, and a ring was attached to the upper end of the bar for convenience of handling. This bar was driven, by means of an ordinary pile driver, down to the desired depth—when withdrawn, a hole was left the size of the bar, in which was placed a tin cannister containing about 13 pounds of powder, which was done by means of a diver in submarine armor. The charge was fired by means of a battery, resulting in the displacement of a large quantity (comparatively) of material. The experiments with a single bar proved so successful, that two other bars were procured, one of which was six inches in diameter, and both 22 feet long. By means of these additional piles, two pile drivers and crews, one diver and an assistant, from 20 to 40 blasts per day were effected at a depth of eighteen (18) feet below mean high tide.

After the bottom had been gone over in this way, the dredges would excavate, in a single day, from 50 to 120 yards of material. It will be noticed that there is a large economy in the above method of submarine blasting over drilling. Occasionally a pile would get immovably fast between the boulders, when it had to be loosened by adjacent blasting. Without having tabulated the items of expense, it is supposed that the cost of moving the material will not exceed $4 per yard, and, possibly, not $3.

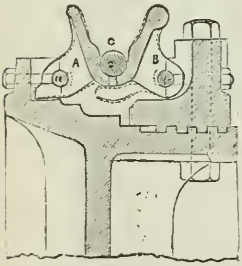
The caisson was launched without a mishap on the 19th of March, in the presence of a large concourse of spectators. It was an interesting sight to see the unwieldly block slide off her ways, and although weighing nearly 4000 tons hardly glide two hundred feet into the river before being brought to rest. To prevent the possible contingency of pitching into the mud before it cleared the ways, the outside end was artificially buoyed up by casing in, as it were, the forward part of the air chamber, which had the effect of canting it up as it struck the water. The whole operation lasted hardly ten minutes, and there fortunately proved to be no use for the half dozen steam tugs in waiting, which had been provided in case the caisson stuck on her ways. In a few days the excavation will be ready, when we may expect to see active times in the neighborhood of Fulton Ferry. A. P. B.

The Clip Pulley.—At a late meeting of the Franklin Institute, mention was made of the successful application of this improvement at the inclined plane at Tipton, in connection with the iron mines there located upon the Gregory tract.

This invention has been introduced from England, where it has been successfully used and highly commended for its many advantages. The following is a short description of its construction and action.

The circumference of the pulley, driving the wire-rope, is set throughout its whole extent with numerous pairs of movable jaws, each pair being separated from the next following by an interval sufficient to admit of mutual freedom of motion. A transverse section of the rim of the pulley is represented in the figure—showing the construction and disposition of the movable jaws or clips by which its peculiar action is obtained. The letters A and B indicate the jaws attached loosely upon the pivots *a* and *b*, while the depression is occupied by the rope C.

It will be noticed that any strain or pressure, applied in the depression, will produce a downward and inward motion in the lower, and like motion in the upper extremities of the jaws, bringing these nearer each other; the result of the whole motion being that the body producing the strain will be tightly clutched and held immovable. It is evident, too, that the amount of the motion of the jaws, and hence the amount of the clutch to which the pressing body will be subjected, is directly proportional to the pressure or strain which it exerts upon the depression. This is precisely its action upon the wire-rope, the movement being indicated in the figure by the dotted lines.

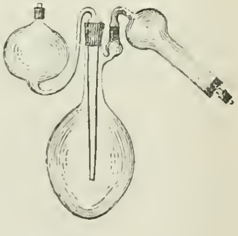


This peculiarity of the clip-pulley permits of the application of a wire-rope driven at a low speed, which, as machinery of this kind, requires to be kept constantly in motion, to avoid the troublesome delay of repeated startings, implies a decided economy of power, in as much as the force expended in driving the rope while the machine is idle is reduced to a small figure; while, when employed, the speed of the rope remains unaltered and unaffected by the speed of lifting, the effect of any change in the latter being merely to increase or decrease the strain upon the rope.

In addition to the advantage of low speed, it is remarked of the clip-pulley "an important practical advantage attending its use, is that it entirely does away with the sawing action of the rope in the ordinary V groove of a pulley—the clips laying hold of the rope with an amount of grip proportionate to the pull upon the rope, holding it absolutely fast for the moment and afterwards completely releasing it as soon as it arrives at a point where it is tangent to the pulley. By this means, any power that is desired can be transmitted by the clip-pulley, without involving either the loss from friction or the wear and tear of rope attending the use of the ordinary grooved pulley."

Carbonic Acid Apparatus.—Of the numerous contrivances designed for the quantitative determination of carbonic acid (nearly 20 have been described) there are none which, with very satisfactory results, combined more simplicity of construction and ease of operating than that here figured.

It is upon the plan of Mohr's well known apparatus—the main difference between the two being, that in the latter both the acid and drying tubes are introduced into a single-necked flask, through a doubly perforated caouchouc cork, while in the apparatus figured here the two are introduced by separate necks, by which means the greatest ease and security in fitting together and taking apart is attained, without materially adding to the complication; but in these and other respects adding much to convenience. The bulb in the tubulus of the flask is furnished with a loose wad of cotton, which serves the purpose of retaining much of the vapor evolved during an operation, before it can reach the ordinary drying tube. If the acid used in the analysis is hydrochloric, the ordinary drying tube is



laid aside, generally, for one of similar construction, but containing chloride of calcium in the one half, and bits of pumice, saturated within and without with anhydrous sulphate of copper, in the other. The two substances kept apart by a layer of asbestus. The details of the apparatus and its operations will be evident from the figure.

The ends of tubes are closed by means of short pieces of rubber tube, fitted with fragments of glass rods. W. H. W.

Corrosion of Iron Water Pipes.—We are indebted to Mr. Fred. Graff, Chief Engineer of the Philadelphia Water Department, for the following curious item. Two wrought iron pipes, seven feet in diameter, have been laid on the aqueduct bridge, by which the Croton water is carried over the Harlem River and much trouble has been experienced from their rusting, but on examination it appears that at each joint, where a lap of some 15 inches is made, no notable amount of rust is formed on the entire belt under the lap. It was, at first, supposed that some molecular change, produced by the riveting (which is double) was the origin of this protection, but this idea is opposed by the fact that the rivets in other parts show no such action, and that the protection in the laps is not concentric with the rivets but stops abruptly with the edge of the lap. Mr. Graff also informs us that the plan of painting the pipes, when hot, with boiled coal tar has met with uniform success in his experience, and also at Boston, where very serious difficulty was before experienced by stoppage from accumulation of rust. An attempt to protect the Croton pipes, by strips of zinc, entirely failed.

High Pressure Converter.—Mr. Bessemer has patented a method of conducting his process under pressure, by means of which, sufficient heat is produced to retain complete fluidity in the steel until it is poured into moulds. For this purpose he makes the converting vessel of great strength and as air tight as possible, and makes the mouth of it circular instead of oval and of smaller size than usual, lining this mouth with a ring of well burnt fire-clay or a composition of clay and plumbago. Mr. Bessemer states that for the conversion of the purer kinds of Swedish charcoal pig iron and for mottled or white hematite pig iron mixed with grey, a back pressure in the vessel of from 8 to 15 lb. on the square inch wil give good results, and in but a few cases will a pressure of 20 lb per square inch be necessary ; while a pressure as low as 3 or 4 lb will be of little practical advantage, and below 2 lb. per squar inch he lays no claim to an useful effect.

Petroleum for Heating Locomotive Boilers.—Two engines on the Strasbourg line have been fitted with M. Deville's furnaces, and are employed in the goods traffic. The consumption of oil in the engines drawing heavy trains is stated to have been from three and a half to five kilogrames for every kilometer traversed, or (say) from 8 lb. to 12 lb. for every two-thirds of a mile. The oil is said to be very completely burnt, and there is no smoke and consequently no waste. Another advantage claimed is, there being no sulphur in the oils the atmosphere of the tunnels would be free from that most disagreeable and obnoxious contamination, sulphurous acid.

A New Method for Drying Vegetable and Animal Substances.—This consists in filling a vessel half full with fused chloride of calcium, pouring ether upon it, and then placing above t a vessel containing the material to be dried. The vessel is placed upon a glass plate, and over this a bell glass, fitting completely to ts surface. The chloride of calcium abstracts the moisture from he ether, which then constantly takes away a new quantity from he substance in the vessel above, until it is quite dry. Articles dried in this manner have quite a different appearance from those from which the moisture is removed by the ordinary process; vegetables retaining their natural color and animal substances their lasticity and flexibility.

The ether, perhaps, dilutes the pores or fibres and thus assists he removal of moisture. Its shrinking action or sponge is, however, opposed to this theory.

Test for Impurities in Alcohol.—The use of impure alcohol or the solution of aniline dyes has a marked effect on the colors. f empyreumatic oil is present much of the brilliancy is destroyed, nd the presence of aldehyde has a still more prejudicial effect, one-uarter per cent. being sufficient to decolorize the violet dye in a ery marked degree. A simple test for ascertaining the purity of he alcohol is to put some in a test tube with a little piece of caus- c potash, when, if impure, the alcohol will become more or less ellow. Another test is to make two solutions of the color of the ame strength (1 in 50), one with alcohol of known purity, and the ther with the suspected alcohol, and then compare the intensity nd shade of the solutions.

A new Hydrometer has been invented by M. Baudin, in which he strength of the spirit is measured by its expansibility.

Editorial Correspondence.

PHYSICAL CONSTITUTION OF THE SUN.

Editor of the Franklin Institute Journal.

SIR:—In November last I presented to the Academy of Arts and Sciences in Boston, a summary of the arguments which had convinced me of the general correctness of Mr. Faye's theory of the sun's constitution; and added some new considerations which had suggested themselves, regarding the nature of the chromosphere and the probable age of the sun. Some of these ideas were also given in a letter to Mr. Faye, from which he has published extracts in the *Comptes Rendus* of the Paris Academy, and others are in my report to Prof. Coffin, on the eclipse of last summer; but, perhaps, it may not be amiss if I reproduce them somewhat more fully at present.

The solar atmosphere, consisting, apparently, of such portion o the sun's exterior as has not suffered condensation into the incandescent form, is not dense nor hot enough to manifest its glow to the eye, nor to the photographic plate except during a total eclipse after long action in the focus of a large object glass; notwithstanding the richness of the hydrogen light in photolytic rays. Bu where those elements which are continually replenishing the photosphere are undergoing their condensation, this atmosphere becomes luminous by reason of their light. Jets of hydrogen mingled with vapor of other and more condensible metallic elements are driven out from the sun's interior between the granules of the photosphere and through the "pores," or round dark points so thickly scattered over the surface, and present the phenomena of the protuberances Rising to a greater or less height before condensation, according to the force with which they are ejected, and thus producing the widely different types of shape which the protuberances exhibit they gradually disseminate themselves over the visible surface of the sun, both by the direct action of gravity after their condensation and by their diffusion as gases before and during this process Acquiring brilliancy by virtue of their change from the gaseou to a more radiant form, they illuminate whatever region they may occupy. Especially when falling as a fiery rain, around the large fountain-like protuberances, they appear as the fleecy aggregations frequently manifested during total eclipses and so much more distinctly upon the photographs than to the eye. Thus the aggregations of luminous matter seen during the total eclipse of last August, at various parts of the sun's limb, but especially in the region near the antelope-horn protuberance, (which in the more delicate photographs presents a truly fountain-like appearance) would be explained as resulting from protuberance-material projected to a greater height than ordinary, and in process of subsidence during condensation; a phenomenon similar in kind to those protuberances which appear to float like clouds above the surface of the sun, without exhibiting any points of attachment.

It is natural to assume that hydrogen, being probably the lightest, and certainly among the lightest, vapor in the sun, would constitute a large portion of the permanent atmosphere outside the luminous shell or photosphere. This outer atmosphere must contain in its lowest strata all those elements whose lines appear dark in the solar spectrum, yet it ought not to be expected that with its relatively feeble luminosity it should exhibit all the corresponding bright lines.

Thus we should obtain the phenomenon observed by Janssen and Lockyer as the "chromosphere,"—a shell or envelope of luminous material outside the photosphere, exhibiting the hydrogen spectrum combined with that of other metals, and identical in substance with the protuberances. Thus we should find its surface listorted and billowy in the neighborhood of the larger protubernces, and its height varying greatly in different regions and at lifferent times. Thus on the photographs of short exposure it vould be found to exhibit protuberance-like aggregations, where he red jets were unrecognized by the eye, and where to the specroscope its surface might appear approximately parallel to the isible contour of the photosphere. Thus the same influences vhich render the protuberance-jets infrequent near the poles would nake the height of the chromosphere there a minimum likewise. nd thus, moreover, the different degrees of density in the solar tmosphere at different altitudes, the difference in amount of the eadily condensible material emitted at the several parts of the imb at different times, and the difference of force with which the mission is effected, would give totally different outlines to the hromosphere, according as it should be seen by means of a rapidly taken and strongly intensified photograph during eclipse, or by th spectroscope, or by a protracted exposure in a small and intens focus.

The approximate similarity of the general outline of the glov around the sun during totality, in its polar deficiency, seems t show that all the photographs, however dissimilar, offer views o one and the same object. This object seems to be that which th spectroscope shows as an envelope of varying yet comparativel narrow thickness around the sun ; and the outer limit of this visible envelope seems to be what we might call a surface of equa condensation, and possibly is the upper limit for some one or mor of the more conspicuous metals.

The wide distinction between this luminous atmosphere and th apparently larger and differently formed corona has been commente upon in a former communication. A complete criterion for distinguishing between the two phenomena is afforded by the ver marked diminution of the one near the extremities of the sun' axis of rotation,—a characteristic which found no analogy in th visible corona last August, so far as may be inferred from th drawings, no matter how crude or hasty, which have come to m knowledge. There seems room for no other conclusion than that tw phenomena are superposed; the one, and the smaller in angula magnitude, being intimately connected with the solar rotation while the other is entirely independent of it, and possibly even o telluric origin.

The researches of Helmholtz and Thomson regarding the age o the sun as a source of cosmical heat have shown us limits, withi which, in the absence of more decisive evidence, we must restric our theories as to the length of time during which he has warme the earth. The contraction-theory has been most ably discusse by these eminent physicists, and seems to afford the only satisfactor mode of accounting for the solar light and heat, now that we knov both that the meteors generally revolve in cometary orbits, an that the habitability of the earth, as well as the apparently unchanged mutual attraction of the planets, bears testimony to the incorrectness of the meteoric theory. From Pouillet's data, (derive from experiments which ought to be repeated in some year whe the solar spots are at a minimum,) Helmholtz has shown that, eve were the sun's density uniform, a contraction of $\frac{1}{10}$ of 1 per cent in his diameter would evolve 20,000 times the present annua supply of solar heat. But when the sun was hotter the same proportional contraction would have evolved yet more heat; so that we must consider the above estimate as a minimum.

The expansibility of hydrogen gas for 100° C. is 0·3661. No gas appears to have so small a coefficient as 0·360, which would correspond to a linear expansion of 0·108. The expansibility of glass, the smallest known, I believe, even for a solid, is about $\frac{1}{150}$ part as great; say 0·00244 in volume, or 0·00081 linear. Therefore for glass even, a contraction of 1 per cent. in diameter would imply a fall of temperature by 1230° C., and a mean specific heat of 218. This seems certainly a minimum value.

But if we suppose the expansion-coefficient to be as large as that of hydrogen, a contraction of 1 per cent. would correspond to a change of temperature by 8·2° C. or a mean specific heat of 32700, if equivalent to 20,000 years' supply. This is out of the question.

Now Thomson has computed that bodies smaller than the sun, falling from a state of relative rest at mutual distances which are large in comparison with their diameters, and forming a globe equal to the sun, would generate 20,000 times the present annual supply. This would be greater did we consider the unquestionable increase of the sun's density toward his centre. And since it seems out of the question that resistance and previous minor impacts could have consumed more than one-half the heat, he inferred ten million times a year's supply to be the lowest, and one hundred million times to be the highest, estimate of the sun's initial heat.

Now we have every reason for the belief that radiation is proportional to temperature. Assuming this and taking the temperature of the sun's photosphere as 14,000° C.,

10,000,000 times the present annual supply would be radiated
in 3,650,000 years if the specific heat were 218,
in 7,280,000 " " " " " 1000.
00,000,000 times the present annual supply would be radiated
in 8,250,000 years if the specific heat were 218,
in 25,500,000 " " " " " 1000.
00,000,000 times the present annual supply would be radiated
in 11,700,000 years if the specific heat were 218,
in 38,900,000 " " " " " 1000.

For vapors, other than hydrogen, the greatest known specific eat, so far as I am aware, is 0·508, (ammonia); and hydrogen, which has less than 3·5, cannot form any considerable portion of the sun's mass.* A specific heat so high as 1000 seems altogether out of the question; yet it will be seen that even on this supposition, an amount of initial heat equal to 500,000,000 times the present annual supply, would have been radiated in less than forty million years, were the sun's radiative capacity proportional to his temperature. Taking the more probable age, 10,000,000 years, we should find 226 million times the present annual supply to have been radiated within this period if the specific heat were not greater than 218; and even were the specific heat as high as 1000, the total radiation would have been 18 million times a year's radiation at present

Thus the limit given by Thomson, although so vastly below that afforded by the speculations of some geologists, would appear itself to demand a considerable additional reduction. And I cannot see how we can well suppose the sun in its present form to have radiated heat for more than twenty millions of years, while three or four millions would seem to be a far more probable estimate unless the thermic laws be totally different in those exalted tem peratures which we must suppose to have existed at some past epoch.

The very great diversity of the limiting values for the specific heat seems to afford ample scope for every needful allowance on account of the natural action of the particles within the body o the sun, even conceding to this the immense effect (analogous to the increase of specific heat) which has been assigned to it by some investigators. Even did we concede a primitive heat equal to 200,000,000 times the amount now yearly radiated, and a specific heat 10,000 times as great as is possessed by any known gaseous body excepting hydrogen, we could not deduce so long a period as 80,000,000 of years for the past duration of the sun's heat.

Yours, &c., B. A. Gould.

Steel Engine Cranks.—Vickers & Co., Sheffield, have cast th second of the two largest steel cranks ever made. Its weight wa 38,500 pounds. Five hundred and fifty crucibles were poured in regular order in making it.

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* It seems to form certainly not more than the 18,00 th part of the mass of th earth

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 197.)

Varieties of Belting.

"An examination of the different leather departments, and the varieties of belting in actual use, reveals a tendency on the part of manufacturers to improve the quality of wide belts by securing 2 inch strips along their edges. Specimens of this character are exhibited by Messrs. Webb & Son, Stowmarket, England; Mr. William Ruland, of Bonn, Prussia; H. Lemaistre & Co., Brussels, Belgium; Placide Peltereau, 32 Rue d'Hauteville, Paris; Poullain Brothers, 99 Rue de Flandre, Paris; and others, of less note.

The material forming these strips is (with a single exception) leather of the same quality as the belt. The methods of attachment are variable, as laces, threads, rivets, eyelets, and brass screws. The English use the threads, Prussians the laces, and the French all the varieties enumerated. Mr. P. Peltereau, proprietor of one of the largest houses in France, makes a remarkable display not only of belts and their mountings, but of different kinds of leather, such as tanned elephant hide, varying in thickness from $\frac{1}{4}$ to $\frac{1}{2}$ an inch, and hippopotamus hide from 1 inch to $1\frac{1}{2}$ inches in thickness.

His 8-inch and 10-inch belts have leather facings 2 inches wide on their edges. Each of these facings is attached by two leather laces, whose stitches have $\frac{3}{4}$ of an inch span, and run in parallel lines separated by $1\frac{1}{4}$ inch.

The "inextensible belt," for which, at a previous exposition, he received a gold medal, has steel instead of leather edging strips. These strips, for a 10-inch belt, are 2 inches wide by $\frac{1}{64}$ of an inch in thickness, and are attached by two rivetted rows of copper tacks. These tacks are $\frac{1}{8}$ inch diameter and placed $3\frac{1}{2}$ inch between centres.

Messrs. Poullain Brothers join their single and compound their double belts with headless $\frac{1}{8}$ inch brass screws. This is accomplished by a very ingenious machine, of which there are several types in the French department. It carries a coil of plain brass wire, which, while being fed to the work, passes through a die of 28 threads to the inch. The screw thus formed enters the belt at a point closely clamped by a foot-lever, and having passed through is cut off. Finally, the belt being placed on a surface plate, the points of all the screws are slightly riveted. The most compact and expeditious of these machines is the invention of Mr. Cabourg, 74 Rue St. Honoré, Paris.

Mr. E. Scellos, of 74 Boulevard du Prince Eugène, exhibits what he terms a "homogeneous belt," for 150 horse-power. This belt is 19½ inches wide by ¾ inch in thickness.

It is composed of 104 leather strips ¾ inch wide, laid horizontally with reference to the belt, and laced transversely; the distance between laces is 1¼ inches, and diameter of lace $\frac{3}{16}$ of an inch. The advantage of edge-bound wide belts, where frequent slipping is an essential, we think will be readily conceded; and to what extent they can supplant double belts is a subject worthy of experimental inquiry. The use of very wide belts is seldom resorted to in the machinery department. One of the stationaries has two central ribbed pulley rims bolted to the arms of its fly-wheel, on these run 4 belts 6 inches in width; another has two 12-inch edged belts, and so on—the inclination was always to increase the number rather than the width of the belts.—*Report on Steam Engineering, Paris Exposition*, 1867.—*W. S. Auchincloss.*

(To be Continued.)

LONG SPAN BRIDGES.

[The following letters, of which only a few printed copies have been circulated, possess so wide an interest that we think them well worthy of a place in our pages.—Ed.]

U. S. Engineer's Office, St. Paul Minn., Dec. 21, 1868.

To Mr. W. W. Evans, Chief Engineer, and others,
Members of a Convention held at St. Louis in August, 1867.

Gentlemen:—I respectfully request your consideration of the use that has been made of your report in a pamphlet circulated among members of Congress at the last session, and would like to be informed by you, individually, how far you intended to decide the question of bridging the great navigable western rivers. It did not seem to me that anything more was intended by the Convention than to "recommend to the parties in interest," viz: "the Bridge

Company," what you deemed was for their interest, and I think that may be clearly inferred from your report. Nevertheless, there are expressions used in different places in it which seem to indicate that the conclusions reached were general in their application, and I have thought it best to refer the matter to you. I have taken from the pamphlet, to which I call your attention, its title page, and all there is quoted from your report.

In order that you may understand why it is that *I* bring this matter before you, I will state:

That in August, 1866, I was assigned to the duty of collecting information in relation to bridging the Mississippi River between St. Paul, Minn., and St. Louis, Mo., under a joint resolution of Congress past just previous to my being thus assigned. I have been engaged upon this, with other duties, ever since, reporting progress, from time to time, to the Chief of Engineers, U. S. Army, and conferring and communicating with the Senate Committee on post offices and post roads, at each session.

At the last session, the question of bridging the Ohio River was brought prominently forward, and I was consulted by this same committee in relation thereto. The report of this committee you can probably obtain by writing to a member of Congress. It forms printed Sen. Rep't, Com. No. 168, 40th Congress, 2d session.

The substance of what I am responsible for in that report, is that a 500 feet span (not a suspension one) is practicable, and with the contiguous spans of the ordinary length, with single track, at an expense not greater than for such bridges already built in this country, and that the interests of the navigation should determine whether such long spans were necessary, as it might be in some cases and not in others. I did not then think that I was at variance with the St. Louis Convention; that Convention had decided the question as far as it related to the Bridge Company's interest, and to the effect, that the cheaper the bridge the better for them, while I had given my opinion that the necessities of navigation should decide it, provided these were not so exacting as to be practically prohibitory to bridges.

The debates on the subject in the Senate on July 16th, 17th, 21st and 22d, (see *Globe*,) show that very considerable importance was given, in the minds of some members of the Senate, to the extracts from the report of the St. Louis Convention, one Senator using the following language: "I wish to read a few extracts from "a longer report now in the hands of the Senator from Indiana. As "we cannot get any other reports to know whether this [the report "of the Senate committee] is right or wrong, I shall be inclined to "rely on this report of 25 civil engineers, one of them, however, being from the United States Army." Extracts were then read from this pamphlet, and the Senator concluded: "Mr. President, I "am bound to believe, until I see something to the contrary from "some authoritative source that this idea of a five hundred feet "span, is a mere notion, gotten up by one opposing interest against "another."

I hope you will not take this reference of the matter to you, by me, as an unwarrantable intrusion. I would be obliged to you for such answers as you choose to make, and I would like to have them sent me with the understanding that they may be officially used by me in my reports.

I, myself, attach the highest value to the decision of a body composed of such distinguished engineers as constituted that Convention, and as it is not a permanently organized body, I have addressed this to you individually. The weight which your decision must carry with it, must be my excuse for endeavoring to ascertain "authoritatively" what that decision practically was, and its extent and application. The question has not yet been disposed of in Congress.

Yours, respectfully, G. K. WARREN,
Major Engineer, U. S. A.

New York, January 5, 1869, 47 *Exchange Place.*

GENERAL:—I am in receipt of your circular letter in reference to the report of the convention held in St. Louis, in August, 1867, to consider the subject of the construction of a Rail and Highway Bridge across the Mississippi River, at St. Louis. In answer, I would say, that, although my name appears as one of the Convention, I was not present, and did not see the report until after it appeared in pamphlet form. The President of that Convention was my chief for a number of years, and having always had the most exalted opinion of his great Engineering ability, I told him that I would sign the report; that I would sign anything that he would put his name to. In this way my name became attached to the report. I beg now to say, in reference to the question asked, that I fully believe in the practicability of building Girder Bridges of 500 feet clear spans; but, I do not believe in the propriety of them in any case or under any circumstances; but, I do believe in the propriety, the economy, the reliability, and the usefulness of bridges of suspension for railway and highway purposes, of spans ranging from 500 feet to 3,000 feet. Why the law should have been framed to exclude the Suspension principle is, to me, inexplicable, when we have in existence a railway bridge of much greater span which has given satisfaction. That bridges, on the girder principle, of 500 feet spans can be built there is now no longer reason to doubt, with the knowledge we have of the construction of the Britannia Bridge, 459 feet 3 inches span, and the bridge just constructed over the Lek, at Kuilenberg, in Holland, of 492 feet span, and another over the Moldau, at Prague, in Austria, of the same span, but I would ask, What engineer is there in the United States bold enough to recommend such bridges for construction here, when he has, staring him in the face, the figures 2,123 as the tons of iron and steel used in the construction of one span of 492 feet, and the figures 3,000 as representing the tons of iron used in one span of the Britannia bridge of less than 460 feet, and then compare these figures with the 400 tons of iron and less than 600 tons of wood used by Roebling in the construction of the Niagara Suspension Bridge, of over 800 feet span? I am fully convinced, after years of investigation, that bridges of 500 feet span, of iron and steel, for railway purposes, having no curved lines in any of the chief members, and having as much rigidity as the Britannia Bridge, can be built, and successfully built, on the Truss Suspension principle, with much less than 700 tons of metal. Fink's Patent Suspension Truss Bridge as now built by an eminent engineering firm of Baltimore, and very extensively used throughout the country in spans of 250 to 400 feet, combines many of the features required in a railway bridge. This plan may, in my opinion, be improved for very long spans by introducing a plan for keeping the main suspension members in straight lines by auxiliary chains, as supporters of the sag which would naturally take place, this feature in bridge building will, before long, be understood, appreciated and used for railway bridges of very long spans. I see no good reason why railway bridges of 1,000 or 1,500, or even 3,000 feet span should not be built when occasion and circumstances call for them; but, spans of these dimensions evidently cannot be built when the chief members are arches, depending on compression for strength; bars, or beams, or columns, beyond a certain length, cannot be depended on for strength without much lateral bracing and propping on every side, and even then no man can tell when and where buckling and doubling up will take place, while a bar or chain of iron or steel, or cable of wire, has a known strength no matter what the length, and can be relied on.

The suspension principle is fully understood and appreciated by the leading engineers of the United States, and it is folly for legislators and others at the present day to ignore its great merits. Mr Roebling deserves much praise and lasting honors for the boldness exhibited in design, and the skill developed in execution of railway bridges of suspension, and that, too, after the matter had been discussed and condemned by the Institution of Engineers in England. It is shown by actual results that the deflection of the Niagara Suspension Bridge, which has a span of 821 feet 4 inches, is about the same in proportion to the span, as that of the Britannia Bridge, a rigid Iron Plate Girder of 459 feet 3 inches, when each are loaded with 300 tons. When the Niagara Suspension Railway Bridge became a fixed fact, European Engineers made it the subject of much discussion; many of the routine Engineers, those that had been brought up in a groove, could not believe in it, and do not believe in it to this day; but one among them, a well-known writer on the strength of materials, Peter W. Barlow, packed his valise and came to this country to look at this wonder after it had been in existence over five and a half years. It may be interesting to quote some of his opinions and conclusions taken from a pamphlet published on his return to England, a copy of which he sent to me. On page 6 he says: "The suspension principle, if correctly carried out, is the "safest, as well as greatly the most economical application of iron "to railway structures." On page 18: "Oxidation is slow where "every part can be got at and painted. Tube Bridges, with cells, "difficult to be got at, will be more liable to loss of strength from "this cause." Page 19: "The durability of the Niagara Bridge "Cables will not be less than the masonry of which the towers are "built." At page 22 he shows the ratio of strength to strain, by "weight of bridge, to be in the Niagara Bridge, 6·5 to 1; in the "Britannia Bridge, 3·4 to 1; the Conway Bridge, 3·8 to 1, and the "Satash Bridge, 5· to 1. Page 30: The Niagara Bridge is the safest "and most durable railway bridge of large span that has been constructed; had wrought iron been used for trussing, the total "weight would not have exceeded 800 tons, the deflection of the "wave reduced to 2 inches, and the strain on the cables to $\frac{1}{8}$ of "their ultimate strength. It is clear, therefore, that 820 feet is not "the limit of the opening that can be crossed by this principle, but "that spans as high as 3,000 or 5,000 feet can be carried out for "railways without exceeding the safe limit of strain on the wire "cables, and at a cost which would render remunerative connections and communications, which are now considered impracticable." Mr. Barlow then goes on to estimate the dimensions strength and cost of a suspension bridge of 3,000 feet span, which he proposed to build between Liverpool and Birkenhead. From the foregoing notes and opinions of one of the first of English Engineers, together with what we know and can see for ourselves, who is there that can doubt? Who is there bold enough to ignore the strength, the economy, the safety, the durability, and the great merits of the suspension principle for railway bridges of great span? I am in the belief that a very large portion of the educated people of this country are ignorant of what can be done with steel, and how differently it will act under certain circumstances of tension and compression. It is common among Engineers to demonstrate facts, and show differences by caricatures. Let us take this method to show what steel can do in tension, and what it cannot do in compression.

Suppose steel wire to have a tensile strength of more than 150, 000 pounds to the square inch, also that one inch cube will have a compressive strength of more than 150,000 pounds, (there is plenty of steel to be found that can exceed these figures,) now let us suppose that four cubic inches will weigh one pound, which in round numbers is not far from the truth, there will be 50,000 feet of solid steel wire, one square inch area, in 150,000 pounds, and there will be tensile strength enough in the first inch at top, if in one piece, to hold itself if suspended from a point 50,000 feet above the earth and hanging in a straight line; now suppose we rest the lower end on a well prepared foundation and let go of the upper end, what will become of the 50.000 feet when you come to depend on its compressive strength? Is it not clear that it will double up in a thousand folds and twist and come down to the earth with a rush, and yet the first cubic inch at the bottom was prepared to hold the whole of it without crushing. Suppose we take 3,000 feet of this one inch square solid cable of steel wire and hang it on a hook 3,000 feet above the earth. What will it hold? Why it will hold itself, which will weigh 9,000 pounds, and a ball of 141,000 pounds, which is the balance of the 150,000; but what will become of the 3,000 feet if compression is depended on, to say nothing of the 141, 000 pound ball? Why it will come down as before. What will become of 10 feet of this cable, or 5, or even 2 feet, if it were set up and the 141,000 pound ball or the tenth part of it were placed on top? Why it would buckle, and the ball would have a tumble.

This is not a very scientific way of writing, General, but it is one everybody can understand, and I only write in a caricatured light to show in this ridiculous way the true difference between compression and tension in long span bridges, where economy and reliability are considered, and where the Engineer is performing his chief function, of making the most out of the least.

I remain, General, your obedient servant,

W. W. EVANS.

To GENERAL G. K. WARREN,
U. S. Engineers,
In charge of Mississippi River Surveys and Bridges.

Slate Pencils for the Million.—A Rutland (Vt.) Slate Pencil Company has recently put up a machine which will cut, it is said, 20,000 pencils in an hour.

A New Explosive has been invented by Mr. Nobel, inventor of nitro-glycerine and dymanite, which he calls dualine. It consists principally of nitrate of ammonia and very fine saw dust, which has been acted upon by nitro-sulphuric acid. It is said not to be decomposed by accidental contact with acids, will not congeal or lose any of its properties during cold or hot weather. Its explosion does not produce any noxious gases, and it will burn in the open air without exploding.

PUMPING ENGINES.

By H. P. M. Birkinbine, Engineer.

On page 19 of the January number of the *Journal*, appears an article under the head of "Performance of Engines," in which there are statements of the *duty* of a number of rotative engines, driving elastic loads, brought into comparison with the performance of Cornish pumping engines; as an answer to former communications.

The question discussed in the *Journal* is not that no other form of steam motor could possibly give as high a *duty*, but simply that for pumping water the Cornish engine is the best adapted to the work, and that it will raise more water, with a given amount of fuel, than any other known form of engine.

America may be proud that her mechanics have done so much to improve the efficiency and workmanship of the steam engine, and that those made by them compare favorably in proportion, finish and performance with the best productions of other countries; yet, for pumping water, we have not succeeded in making any engines which equal in duty the Cornish engines instanced, viz:

Fowey Consols	1,160,714 foot pounds.
Rowans	1,767,851 foot pounds.

But little confidence can be placed in mere experimental results as exhibiting the economical value of an engine, for they are generally by or in the interest of the maker so as to give the utmost duty possible under the most favorable circumstances.

In the trial of a pumping engine in one of our cities, two set of experiments were made, one for duty and another for capacity. In another city more than one-third of the coal used during the trial is charged to banking fires, etc. These two instances show the unreliability of some claimed *duties*. In the performance of the various engines of the Philadelphia Water Works, in the report, all the coal purchased was charged, and the average month's or year's work given. This makes them appear to disadvantage when brought into comparison with mere experimental results.

The variety of opinions in regard to the most efficient form of pumping engines is, in some instances, due to the want of knowledge and experience of those called upon to select, design or construct them, and, in others, to an unwillingness to pay for the proper kind of machinery.

The author of the article referred to says "several writers have distinctly stated in the *Journal*, that the weight of the moving parts is the principal cause of the superiority of this form of engine (Cornish) etc." These statements, if made, have escaped my notice; what has been asserted is that the weight of the moving parts makes a higher degree of expansion possible, and so far as this affected the *duty*, it was a valuable consideration.

Steam Jacketting.

My paper on "*steam jacketting the cylinders* of *Cornish engines*" simply presented a few practical statements and was written with the hope that some one with more time, patience and ability would consider the subject worthy of an exhaustive paper; for if these expensive, and often troublesome, appendages to an engine are of little or no practical value it would be better to dispense with them.

No reference was made in my article to the value of steam jacketting any but Cornish engines.

The array of names of world wide reputation to which my position is claimed as antagonistic certainly appear to be sufficient to settle the question; yet, accepting their theories as correct, some circumstances may occur in practice to modify them, and still render my position tenable. Thus the statement given to show that there would be a difference in the diameter of the ends of the cylinder in not using a steam jacket is theoretically correct; but the difference between the steam and exhaust ends would not be 0·1 inch as stated, for the temperature of the exhaust end would not be that of the condenser stated as (90°) (?) and although it is affected by the refrigerating influence, it is doubtful if it is ever below 200°.

The conductive power of the metal of the cylinder, the retentive power of its clothing and the fact that the entire cylinder becomes at every stroke alternately steam and exhaust, will place at least one cipher before the figure given, thus making the difference in diameter ·01 inch. A cylinder eighty (80) inches in diameter and fourteen (14) feet long which could be bored with no greater variation in diameter than this, would be perfectly satisfactory; indeed such accuracy is rarely, if ever, attained in practice. Therefore, the position that *practically* there would be no difference in the diameters of the ends of the cylinders is a true one.

The instance of an engineer attempting to start an eighty (80) inch cylinder engine without warming it up, simply shows that the person in charge was unfit to take care of so important a piece of mechanism, and it is a miracle that the jacket was not broken. No remarks are necessary upon the other engines instanced, as the same erroneous assumption forms the basis of calculation.

There is a practical limit to expansion, and if the full amount desirable or safe can be affected without a jacket, there cannot be any necessity for carrying it further. There are few Cornish engines in which the steam is used in the cylinder at a greater pressure than 45 pounds + the atmosphere. By maintaining a pressure sufficiently above this in the boiler to counteract the loss of heat from various causes in working the steam, may not all the benefits of a jacket be secured in this way?

While the formula given, and the calculations based upon it, show great advantages from jacketting, it does not appear to be realized in practice. In Wicksteed's experimental inquiry into the Cornish, Bolton and Watt pumping engines, Table VII. the amount of steam used in cylinder and jacket is given in several instances (line F, columns 8 and 9 represents about the average.) The amount of water condensed in the jacket per stroke of the engine is ·028 pounds, that required for the cylinder is 5·422 pounds. The relation which these quantities bear to each other shows that any possible gain by the utilization of the heat of the steam in the jacket through the walls of the cylinder, must, of necessity, represent but a small percentage of the work done. At the late exhibition of the American Institute in New York, there were two high pressure engines fairly representing the better class being constructed at the present time, nearly identical in size and arrangement, one with a steam jacket fitted to the cylinder and the other without this appendage. They were tested together with the following results in coal consumed per horse-power per hour.

Jacketted Cylinder.

Indicated horse-power	2·831	pounds.
Net horse-power	3·248	"
Dynamometer horse-power	3·445	"

Unjacketted Cylinder.

Indicated horse-power	2·895	pounds.
Net horse-power	3·209	"
Dynamometer horse power	3·294	"

Yet with these results so identical, a writer upon these experiments claims an increase of duty for the jacketted cylinder, by calculation, of 13·7 per cent.; but it does not appear, in either of the three methods, taken to arrive at the value of the work done; the coal heap being the absolute measure of economy.

The Cornish engine mentioned in my former article, forms a part of the pumping machinery of a canal company, and while its duty is below that of high pressure rotative engines in the same works, it could, at small expense, be made much more economical.

The engine so contemptuously referred to as being in one of the Philadelphia Water Works, is a Cornish engine with its beam placed on the sides instead of overhead, and was constructed by an establishment of long standing and reputation in this city. The "*singular pair of twins* in the West Philadelphia Water Works" I am responsible for, and constructed them in 1854 for Bull Cornish engines, nor am I even now convinced, by the correspondent of the *Journal*, that they are not such engines. When in fair working order they frequently have produced an average duty of over six hundred thousand (600,000) foot pounds for a month at a time, working irregularly, as of necessity they must, without any reservoir, supplying the water, as it is used, through a standpipe.

While we may have no right to doubt the high duties claimed for some of the Cornish engines reported, 130 millions and 198 millions, yet when making a personal examination of the famous Wicksteed engine, which is a part of the machinery of the New River Company supplying London, and making all the allowances which could be fairly given in favor of the engine, I found the average working duty was not above 600,000 foot pounds.

A fair average working duty for Cornish engines is from 500,000 to 600,000 foot pounds. However scientific men, the writer of the article included, may be astonished, it is a fact that the majority of engines now in use, for all purposes, consume on an average over 5 pounds of coal per horse-power per hour, and of those being constructed at the present time a large majority will consume over 3 pounds of coal per horse-power per hour.

The Oliver Evans high-pressure pumping engine, erected at Fairmount in 1815, produced an average duty of 175,000 foot pounds, and there are pumping engines now running which give a lower duty; one a patented duplex condensing engine, highly recommended by a writer in the *Journal* and claimed to "rival the Cornish engine in its best results," now supplying a city in this state, produces an average of but 126,000 foot pounds.

Are not civil engineers as a class much to blame for the confusion that appears to exist in reference to this subject?

The pumping engine forms one of the most vital parts of the majority of our water works. Would it not be well for them to come down to the work-shop and look into the details, making themselves thoroughly conversant with the subject so as to enable them, from their own knowledge, to suggest what form of pumping engine is most desirable, and to prepare their own plans and specifications instead of being dependent upon others, who may be skilled mechanics doing work with integrity, yet unacquainted with the principles embraced in pumping engines, or, as is sometimes the case, to an enthusiastic patentee who can see nothing so distinctly as his royalties.

Having carefully examined most of the different patents granted for improvements upon pumps and pumping machinery, I am satisfied that few of them are of any essential value, and that any one skilled in the matter may design pumping engines of the most efficient character without in any way interfering with patented peculiarities. Thus not only saving royalties, but enabling the work to be let to the lowest and best bidder.

"Squirting" Solid Metals.—In a recent lecture at the Society of Arts, London, John Anderson, C. E., noted this property of metals and described various processes dependent thereupon. In the course of his remarks he said:—"A very singular result was obtained by an attempt to squirt brass pipes, which are extensively used as steam boiler tubes and for gas fitting purposes. This brass consists of sixty parts of copper and forty parts of zinc, and of various other proportions; but, singular to relate, the pipes so squirted were zinc rather than brass; the most of the copper remained in the vessel and refused to flow. We are not to infer from this that the copper would not flow, but rather that the union between the zinc and the copper was less than the pressure necessary to make the copper flow; the mixture may have been more mechanical than chemical, or the temperature may have been such as to have had the zinc too near its melting point. Whatever is the explanation the subject is well worth further experiment."

H. B. M. IRON-CLAD "MONARCH."

By R. H. Thurston, First Assist. Eng., Assist. Prof. Nat. Phil., U. S. N. A.
(Member of the Institute.)

The graceful tribute of respect recently paid by two great nations to the memory of a great philanthropist is incidentally coupled with an admonition that the government of the United States cannot allow to pass unheeded.

The vessel chosen by the British government to send to this country is regarded as one of the most powerful and effective of their iron-clad ships. Of high speed, powerfully armed, and only vulnerable to the very heaviest guns we have mounted afloat, the *Monarch* is a fair representative of the most advanced British naval engineering practice.

A careful inspection of that vessel shows that the British naval authorities have well improved the time during which a false economy has completely checked the growth of our own navy; and it indicates as well, how rapidly engineering science is modifying the methods and the machinery of naval warfare.

It seems every year more probable that the increasing power of guns carried on vessels of war, the consequent increased weight of armor rendered necessary, together with the high speed demanded and its inevitable accompaniment of heavy and bulky machinery, will sooner or later compel the division of the vessels of every navy into three classes of ships—exclusive of torpedo vessels—one for general service in time of peace, the others for use only in time of war.

The first class may consist of unarmored vessels, of moderate size, fair speed under steam, armed with a few tolerably heavy guns, and carrying full sail power.

The second class may be vessels of great speed under steam, unarmored, carrying light batteries and as great spread of canvas as can readily be given them—very much such vessels as the *Wampanoag* class of our own navy were intended to be—calculated expressly to destroy the commerce of an enemy.

The third class may consist of ships carrying the heaviest possible armor and armament, with strongly built bows, the most powerful machinery that can be given them, of large coal carrying capacity, and unencumbered by sails, everything being made secondary to the one object of obtaining victory in contending with the most powerful of possible opponents. Such vessels could never go to sea singly, but would cruise in couples or in squadrons. It seems hardly doubtful that attempts to combine the qualities of all classes in a single vessel as has hitherto been done, will be necessarily given up, although the classification indicated will certainly tend largely to restrict naval operations.

The *Monarch* was built in Chatham Dockyard, England, from designs furnished by E. J. Reed, Chief Constructor of the British Navy, under the direction of the Board of Admiralty.

The system of construction adopted, is intended to combine the special advantages of the "turret system" with fair sailing power, and the result is most creditable to the designer, although it is still his opinion that the broadside system gives best results where the vessel is to be rigged.

We give a view of the *Monarch* on the opposite plate, which is engraved from a photograph taken while the ship was at Annapolis, Md.

The *Hull* of the *Monarch* is of iron, and is built on what is called by Mr. Reed the "combined longitudinal and bracket plate system."

Its length is 330 feet, beam $57\frac{1}{2}$ feet, and depth about 36 feet. The mean draft is $24\frac{1}{4}$ feet, measured tonnage 5102, and displacement 8100 tons. The iron is all of good quality, having a tenacity of over 50,000 pounds per square inch, and an extensibility of nearly one-fifth. A double bottom extends under the whole space occupied by engines and boilers, and up as high as the lower edge of the armor, the bow retreats as it rises above water, and below the surface it has the form shown in Fig. 1, and is well strengthened to serve as a ram; the stern overhang is brought down to the water line and armored in order to protect the rudder-head.

The vessel is ship-rigged, carrying about 21 square feet of canvas to each square foot of midship section, giving a large aggregate but small proportional spread of sail.

The standing rigging is of wire rope, and as the greater portion is in line of fire, it is arranged so that knocking open conveniently arranged catches allows of its being triced up out of the way. The lower masts are of iron, constructed as shown in section by Fig. 2. The main and foremasts are 40 inches in diameter, 90 and 88 feet high, made of $\frac{1}{2}$-inch plate, and the mizzen mast is 36 inches diameter of $\frac{3}{8}$ plate; the masts are strengthened by vertical angle irons and by cross-stays as shown in Fig. 2, at intervals of 6 feet. All other spars are of wood.

The outside plating of the hull varies in thickness from $1\frac{1}{8}$ inch in the garboard strakes to $\frac{13}{16}$ and $\frac{3}{4}$ on the lightest portion of the side.

The armor plating is 7 inches thick along the water line and 6 inches on exposed portions of the hull that are included between two armored athwart ship's bulkheads which enclose the bases of the turrets and the "funnel."

The other parts of the hull are unarmored except that casemates are raised forward to protect two guns pointing ahead, mounted under the forecastle and aft also, to protect a single gun firing directly astern. Fig. 1 exhibits the distribution of the armor.

The armor is backed by 12 inches of teak, and supported by the inner $1\frac{1}{2}$ inch iron skin plating, in two thicknesses of $\frac{3}{4}$ inch each. The inner skin is stiffened, behind the armor, by the ship's frames, 10 inches deep and 2 feet apart, and also by longitudinal frames riveted to the skin outside, and imbedded in the backing but not in contact with the armor plating. In Fig. 3, A represents the armor plate, B the backing, C the vertical inside frames and D the longitudinals.

The athwartship bulkheads have 5-inch armor. backed with 10 inches of teak and a supporting inner skin.

The form of armor bolt used is seen in Fig 4, A is the armor plate, B the inner skin, C the bolt $2\frac{1}{4}$ inches in diameter, X is a rubber washer confined by an iron *cup* washer and its follower Y Y′; a checknut D is generally used but it is not absolutely necessary.

Fig. 5 represents a section of the *Monarch* near the turrets, and exhibits the peculiarities of construction of the hull. A A are sections of the longitudinal frames upon which the strength of the structure so largely depends; the two nearest the keel stop at the ends of the double bottom, the others extend from stem to stern; B B are the bracket plates, which, in this system, are substituted in the double bottom for transverse frames, C C are the transverse connecting angle irons and D the keel plate.

This double bottom is made water-tight, and is divided into compartments like the hull itself; it is also provided with means for filling and emptying each of its compartments as may be necessary to ballast or to trim the ship; its greatest value consists in the safety which it affords against loss of the vessel from injury to the outer skin by the bow of an enemy, by torpedoes or by striking a rock.

Heavy stringer plates are worked on each deck, and the spar deck is wholly of ½-inch iron, with a covering of wood. Above the double bottom, the ordinary transverse framing is adopted. A wing bulkhead E E lends additional security by strengthening the hull and resisting shot capable of penetrating the side armor.

In Fig. 5 H is the 7-inch armor at the water-line, K K the 6-inch armor, O O the backing with its imbedded longitudinal frames, and P P the vertical frames above the double bottom.

The hull is divided transversely by several water-tight bulkheads. One of these bulkheads is placed near the bow, in order that, should the bow be strained or torn open by a collision, the ship may still float safely, another is built at the screw shaft stuffing-box near the stern, two enclose the engine room, two others enclose the boiler space, and another divides it equally, others enclose the magazine and the holds. All openings in these bulkheads have water-tight sliding iron doors fitted.

There is no external keel, its absence being pretty nearly compensated, perhaps, by the "bilge keels" shown at F F in cross-section. A "balanced rudder," similar to those so long used in our own navy is fitted, and its weight is taken on a set of conical rollers at the rudder-head.

Double chain riveting is employed in butts and laps throughout the hull.

The weight of the hull without armor is given at 3674 tons, and the weights carried at 4632 tons. The load draught is 22½ feet forward, and 26¼ feet aft.

The fittings below deck are generally very neat, but not at all extravagant. We noticed that, although gas pipes are led about the ship, and apparatus for making gas is fitted, they are not used, while steam pipes for warming the quarters of officers and crew,—a far more desirable convenience,—were not to be found.

The accommodations for the five hundred and twenty officers and men of the *Monarch* are pleasant, roomy, comfortable and well ventilated. Air ducts are led from all the rooms to the hollow masts which serve as ventilating shafts; the magazines are also ventilated in a similar manner, and the circulation of air may be accelerated by the action of exhausting fans fitted for the purpose.

The *cost of the hull* was not far from £300,000.

The *Turrets* of the *Monarch* are 26½ feet in diameter plated with 8 inch iron, backed with 10 inches of teak and an inner 1¼-inch iron skin; they are strengthened by girders in the same manner as the side armor of the hull.

Fig. 5.

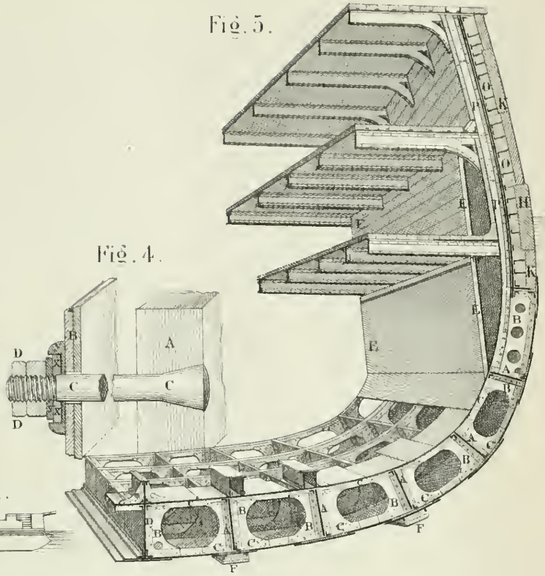


Fig. 2

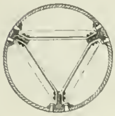


Fig. 4.

Fig. 3.

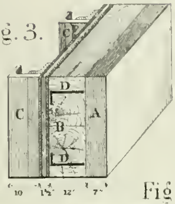
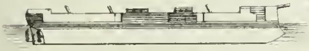
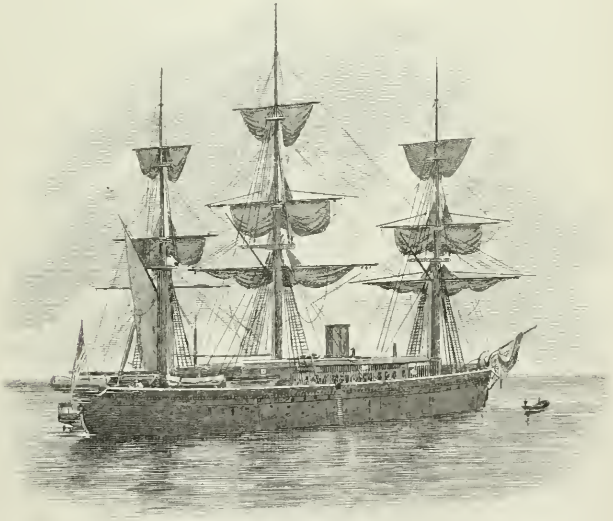


Fig. 1.





Jas. McGuigan [illegible]

On the side in which the ports are cut, the outer plating is 10 inches thick; these plates are 19 feet long.

The turrets rest upon 32 conical rollers, bearing on a circular bed-piece fitted upon the main deck; they rise through the upper deck to a sufficient height to allow the line of fire of their guns to clear that deck, and are only armored where exposed above the upper deck.

The turrets are turned either by hand power or by a pair of engines of about 10 inches diameter of cylinder, and 12 inches stroke of piston. It is claimed by the officers of the ship that the turrets may be turned completely around in slightly more than a half minute. The pilot house or "conning tower," as it is called, is separate from the turrets, and immediately forward the funnel, an arrangement vastly less convenient in action than that adopted in our Monitors. It has no sight-holes, but a reflecting mirror may be used above its open top, to obtain a view of the enemy; otherwise the head must be raised above the protecting shield.

The guns are carried 4 feet above the level of the spar-deck, or 16 feet above the water. The bulwarks are hinged, and in action are let down out of the way of the guns.

The *Armament* of the *Monarch* consists of seven guns, two XII. inch rifles in each turret, two VII. inch rifles in the forward casemate firing ahead or on either bow, and one VII. inch rifle in the after casemate pointing astern.

The XII. inch guns weigh 25 tons each, and throw shot weighing 600 pounds with an initial velocity of 1212 feet per second, and an *energy* of 6145 foot-tons, the charge of powder weighing 70 pounds. At 70 yards they are capable of driving their shot through 13½ inches of iron; their range at 10° elevation is 4000 yards, or 2¼ miles, and at the proving station a maximum range of 5½ miles has been obtained.

The turret guns cannot be trained directly forward or right aft, being restricted in lateral training by the forecastle and other obstructions; the forward turret has been trained to within 19° of the line over the bow, while the after turret guns train within 14° of a line running aft with the keel.

The VII. inch guns weigh 6½ tons each, and, with their regular charge of 22 pounds of English L. G. R. powder, throw a shot weighing 115 pounds, with an initial velocity of 1425 feet per second, and an "energy" of 1650 foot-tons, this energy becoming reduced at 1000 yards to 1140 foot-tons. They are capable of penetrating nearly 9 inches of iron.*

All of these guns are of the regular Woolwich pattern, consisting of an inner tube of "Firth steel," reinforced by two iron cylinders or bands shrunk one over the other.

The XII. inch guns are rifled with 9 grooves, making one revolution in 50 feet; the shot from the VII. inch rifles turn once in $20\frac{1}{2}$ feet. The XII. inch guns have a preponderance of 6 cwt., and the VII. inch guns of 3 cwt. They all exhibit excellent workmanship.

The ports in the turrets are cut very small, and, in consequence, a very novel method of obtaining elevation and depression of the turret guns is resorted to. The carriages of the guns are of iron, very similar in form to those used in our service. The compressors are made like those which were years ago fitted to heavy guns in our Monitors by Captain Ericsson, consisting of a set of timbers lying under the carriage, parallel with the slides of the gun, which are simultaneously clamped by a single motion of the compressing gear, the friction between the beams and the jaws of the clamps resisting the recoil.

The device for elevating and depressing the guns, referred to above, consists of an arrangement of screws and hydraulic cylinders by which the gun is raised bodily in its carriage to obtain depression, or dropped to obtain elevation. It requires five or seven minutes to raise the gun from the extreme of 15° elevation to the other extreme of 7° depression. This arrangement is said, by the gunner, to work well, but, visiting the ship at Portland, we noticed that it was then stated that the hydraulic cylinders were *frozen up*. With the extreme depression of 7°, and the 2° or 3° added by the listing of the ship when the guns are run out, a shot may be made to strike the water at less than 40 yards from the ship's side, a most important point if such a vessel is to contend with low-decked Monitors.

Shot racks are fitted all around the main deck, and tramways overhead from which are suspended the cradles in which the shot are carried, lead to the turrets; trucks are also furnished on which the shot can be wheeled across the deck.

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* With Palliser chilled shot, $P = \sqrt{\frac{W V^2}{400,000 d}}$, where P = penetration of armor plate in inches. W = weight of shot. V = its velocity on striking. d = its diameter.

The *Engines* are of the "back acting" or "return connecting rod" type, steam jacketed, and, with surface condensation, built by Messrs. Humphreys, Tennant & Co.

They have cylinders of 120 inches diameter, 4 feet 6 inches stroke of piston; their "nominal horse-power" is 1100, and they have worked up to more than 8100 indicated horse-power.

The main valves are the common double ported slide, balanced by a ring on the back; they are worked by a link motion. The balance ring moves with the valve, the wearing surface being upon the valve chest cover.

The expansion valve—a gridiron valve driven by an independent eccentric—is rendered adjustable by a half link.

The steam chest cover and cylinder covers are steam jacketed. The main links are of the solid or "sector bar" pattern, and give perfect satisfaction.

Each piston has *four* piston rods, two above and two below the shaft, and the air and circulating pumps are each worked by a rod from the main piston, thus necessitating *six* stuffing boxes in each inboard cylinder head.

The outboard cylinder heads are also fitted with stuffing boxes to accommodate 20-inch half trunks which it has been found necessary to add in consequence of the fact that the great pistons cannot support their own weight—8 tons each—without seriously injuring the cylinder. This multiplicity of openings into the cylinders is certainly a defect in the design of the engines. The cross-head is fitted with "slipper guides."

The frame of the engines looks light but strong, and is well designed.

The surface condensers are arranged, as is very usual in English engines, with vertical tubes $\frac{5}{8}$ inch diameter, 6 feet long, water outside and steam within; they contain 16,500 square feet of condensing surface, equal to about $18\frac{1}{3}$ square feet of surface to each foot of boiler grate surface or equal to about $\frac{5}{8}$ the heating surface. The vacuum obtained during a run down Chesapeake Bay was $27\frac{1}{2}$ inches, without using the jet injection which is also fitted.

The main links are moved by a neat little pair of reversing engines mounted on the platform over the large engines; reversing occupies about 15 seconds.

All the work is well done; very little, however, is highly finished.

The engines drive a two-bladed Griffith screw of 23½ feet diameter, and 26 feet 4 inches mean pitch, expanding 5 feet. Its apparent slip is about 9 per cent., and it works with very little shake; it does not lift.

A "separator" is attached to the steam pipe near the engines.

Water pipes are led to all the journals and the crank-pins are usually kept running wet.

The crank-shaft journals are 3½ and 4½ feet long, and usually run without water, unless at full speed; the lubricant is Rangoon oil.

The cranks carry heavy counterbalances, and at 40 revolutions, the highest number made under our observation, the engines turn their centres very smoothly.

The *Boilers* are of the horizontal tubular kind, and have 20,900 square feet of heating surface, 3,600 feet of superheating surface, and 900 feet of grate surface, or 27·2 square feet of total heating surface to the square foot of grate,

The boiler tubes are 2½ inches by 8 feet, the superheating tubes are 4 inches diameter by 2½ feet long. The dampers are so arranged that the gases may be sent either through the superheaters or to the smoke pipe direct. The "funnel" is oval in section, with a cross area of about 125 square feet, or one-seventh the grate surface. The superheating surface is said to be ample, and the draft, which at full power is urged by blowers forcing air into the boiler room, is all that is desired. The coal bunkers are behind and at either end of the boilers, and the coal is transported without difficulty in large buckets, carrying 400 pounds each, which are suspended from a carriage running on an overhead tramway.

The ashes are thrown overboard by a steam jet which acts like the steam jet pump which is sometimes fitted on board steam vessels as a bilge pump; it is said to work well.

The engines and boilers occupy a length in the ship of 135 feet, and a breadth of 45 feet. The following are their weights:

	Tons.	cwt.	qr.	lbs.		Tons.	cwt.	qr.	lbs.
Engines................	318	5	2	5¼	Spare articles & gear	52	9	3	4½
Boilers................	355	19	3	22¾	Water in boilers....	159	11	3	23
Screws................	14	19	0	6½	Water in condensers	45	0	0	0

The total of all weights in the Engineer's Department, exclusive of 600 tons of coal, and inclusive of bunkers, floor-plates and fittings is 1,136 tons.

The engines and boilers and all their appendages were built, placed in the ship, and the cost of steam trials defrayed by the contractors for the sum of £66,500,—an extremely low price when compared with the expense of building machinery in this country, but not so surprising when it is known that the best class of mechanics are paid but seven or eight shillings per day, in England, and the cost of stock is pretty closely proportioned to the prices paid for labor.

An excellent steam steering apparatus, a powerful capstan engine and a number of steam pumps of large size are also fitted in the ship.

The *Performance* of the *Monarch* is satisfactory under sail or steam. When under sail she carries 20° weather helm with the screw dragging, but with the propeller disconnected it reduces to 7°. Though carrying but two-thirds the amount of sail that is usually given men of war, she has made 11 knots under sail alone. The *Monarch* is a remarkably steady ship, dry in the heaviest weather, yet pitching very little; her maximum roll is stated at 21°. The guns were worked without serious inconvenience during a gale in the Bay of Biscay, when no one of the half dozen broadside ironclads in company could fire a gun.

Under steam, and on the measured mile, with a displacement of 8,070 tons, midship section 1,208 square feet, and mean draft of 23 feet 1 inch, a speed of 14·937 knots on an average horse-power of 7,843—maximum 8,139—was attained, the steam pressure being 31½ pounds, revolutions 63·61—maximum 65—and coal consumption about 2⅔ pounds per horse-power per hour. The formula $\frac{\text{“}V^3.\ M\text{”}}{\text{I. H. P.}}$ gave a co-efficient of 513·4, and $\frac{\text{“}V^3\ D^{2/3}\text{”}}{\text{I. H. P.}}$ gave 171.

On *a six hours' trial* the results were as follows:—Speed, 14,715 knots; I. H. P., 7,470; steam pressure, 30·58; revolutions, 62·67; coal per H. P. per hour, 2·789; co-efficients of performance, 515·3 and 171·6

These co-efficients are low, but that fact is not discreditable to the designer, as it was considered advisable to sacrifice something in this respect, in order to obtain a cheaper and "handier" ship, and the lines were therefore made rather full.

The *Monarch* can steam 125 hours at 12½ knots; 210 hours at

11 knots, or 475 hours at 8 knots nearly, running distances of 1,560, 2,310 and 3,800 knots before consuming her 600 tons of coal.

Acting as a ram, the *Monarch* has an "*energy*" of 33,415 foot tons at 12½ knots, 25,200 foot tons at 11 knots, and 13,040 foot tons at 8 knots, or a destructive power, at those speeds, equal to 5½, 4 or 2 Woolwich 600 pounders simultaneously discharged against the same spot.

The *Magnetism* of the *Monarch* has now become permanent in amount and distribution, with a *maximum* deviation of the standard compass of 10° 30′, and the course may be laid with all the certainty that could exist in any wooden ship.

In conclusion, although we may agree with the designer of the *Monarch*, who, after the designs had been issued, and the ship laid down, stated his conviction that "no satisfactorily designed turret ship with rigging has yet been built or even laid down," and though we may go even further and assert that, very probably, none ever will be designed, it must be admitted that the *Monarch* is a very effective and powerful fighting machine.

Her speed is greater than that of any armored vessel in the world, with the exception of one or two broadside ships recently built in England; her armor, though not impenetrable, will yet enable her to fight a considerable time in an action in which she may choose her own position, without probably receiving vital injury; her guns have the greatest penetrating power of any yet mounted on shipboard, and they can be worked in any weather, while their height above water gives them advantages, in other respects, that should not be underestimated. Her power as a ram is immense, and her construction is such as will enable her, with tolerable safety, to make use of that power. Her spread of sail, though comparatively small, will enable her to circumnavigate the globe if required, independent of steam.

On the other hand, the ship is large, costly to build and expensive to keep afloat; she is not impenetrable to the heavy guns of the present day, to say nothing of those next year, or of the next decade; she is seriously restricted in lateral range of guns, carries comparatively little coal, and is liable to become completely disabled by the fouling of the screw by rigging shot away in action, a danger shared, of course, by all masted vessels.

In our harbors, her great length and depth would be fatal disadvantages.

The *Monarch* is not regarded by Mr. Reed as the most powerful of the British iron-clads. The *Hercules*—a broadside ship of 10 guns—is of about the same speed, and is more heavily plated, although armed with guns 7 tons lighter, and several other ships are nearly as powerful.

Altogether, the British navy contains over thirty broadside, armored ships, with plating from 4½ to 9 inches thick, and nine turreted iron-clads, of which several are true "Monitors" with, in some cases, 12-inch side armor and 15-inch turrets, solid plates being invariably used.

The British navy is yearly increased by the addition of 20,000 tons of vessels, and hereafter it is proposed to add each year 12,000 tons of armored ships.

Although we may to-day be in a condition to hold our own and to defend our seaboard, in case of a conflict with the most powerful of foreign navies, it is to be remembered that we are making no advance, even if we are not rapidly losing what navy we have, while abroad, the necessary increase of navies, and the changes that naval engineering are rapidly bringing about are not disregarded.

The navy estimates of £9,250,000—equivalent in purchasing power to nearly $100,000,000 in the United States, have been recently presented in the British Parliament, and will be probably voted almost without debate, while the estimates of our Navy Department—about one-fourth the latter amount—are, in the House of Representatives, cut down one-third.

U. S. Naval Academy, March 10, 1870.

ENDLESS BAND SAW FOR IRON.

Since the invention of the endless band saw by Mr. J. L. Perin, of 97 Faubourg St. Antoine, Paris, and its entry in the exposition of 1855, the circular plate saw has been rapidly losing ground in public estimation, so that at present every country in Europe is represented by finely finished samples of these wood-cutting tools. In France it has been applied to Ivory, and in Great Britain to iron. The latter adaptation was first made by Colonel Clerk at Woolwich.

In the war department annexed are specimens proving his great success. The first one is an Archimedean spiral (of three turns) cut from a block 9 inches square by 6 inches in thickness. The second is mounted in a glass case on a red velvet background and is composed of a crown on either side of which are the letters "W D," below, the words "Royal Carriage Department, 1867." These were sawed from a plate of iron one inch in thickness.

The letters are quite artistically executed, and the sawed surfaces smooth. The experience of the department leads them to recommend a speed of 250 feet per minute for a band saw cutting one inch iron plates. The teeth of their saws are set and filed straight, having ten to the inch, the width is $\frac{5}{16}$ of an inch.

They use the hardest saw steel that can be obtained, and with soap and water as a lubricant, run the saw for four or five hours without sharpening; the latter operation requires half an hour for its completion. Any curved line can be cut in plates of the above thickness with a feed of $1\frac{1}{2}$ inch per minute. By this system very little waste of material is incurred, and the sawed surfaces are so smooth that they require but slight after finishing. It may not be inappropriate to note that previous to Colonel Clerk's experiments with the band saw, Mr. Krupp used the circular saw for cutting out his steel crank axles, lubricated with soap and water, and found the expedient so much more economical than reduction by a slotting machine that he has continued the practice.—*Report on Steam Engineering, Paris Exposition*, 1867. *W. S. Auchincloss.*

TRANSMISSION OF FORCE BY BELTS AND PULLEYS.

To the Editor of the Franklin Institute Journal.

THE following addition to the paper published sometime since in the *Journal* may afford some facility in use of the results of the investigation then printed. The figures are derived from, and the final results correspond to, the figures given in Table II. of the paper.*

When the arc of contact of a belt upon the least of two pulleys which it connects is

90°	100°	110°	120°	135°	150°	180°	210°	240°	270°

Then the sum of the multiplication together of the inches of diameter of the pulley by the inches of width of the belt, by the number of revolutions per minute which equal one horse-power is

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* See Vol. LV., page 23, of this *Journal*.

3900	3600	3400	3200	3000	2825	2570	2400	2280	2190

Or to make the arc of this perfectly we give the following *rule*:—

To find the horse-power of 33000 pounds lifted one foot high in one minute given out by certain belt, pulley and speed—

Multiply the inches of diameter of pulley by the inches width of belt and by number of revolutions per minute, and divide the result by the numbers given in the last line of figures as relating to the contact the belt has on the smaller of its pulleys, and the quotient will be the number of horse-power.

Machine tools, lathes and boring tools require to be belted three times as strongly as the average are in work, to overcome occasional resistance and starting frictions.

ROBERT BRIGGS.

Gunnery Experiments.—The London *Globe* details some late artillery experiments which showed, that in spite of all possible care in the arrangement, the exact level of the centre being taken on the target by means of a theodolite, the shot would strike ten inches above it. Theoretically, the shot would fall by gravity, and its centre should have struck about two inches below the level. The probable explanation is, that the recoil is sensibly felt before the shot has left the gun, and that the resultant of the forces acting on the gun and carriage tends to throw the muzzle up; thus the projectile, although seemingly fired point blank, really leaves the gun at an angle. With the 12 pounder breech-loading gun this angle was found to equal about thirty minutes, while with the 9 pounder muzzle loading Indian gun it equals about thirteen minutes. The difference is probably due to the projectile taking a longer time to pass through the bore of the breech-loading gun. It may be mentioned that when the gun is swung as a pendulum and fired with its axis horizontal, the shot strikes below the level.

The Insoluble Aniline Colors may be made soluble in water by the following process. A solution of gelatine in acitic acid is first made of about the consistence of syrup, and the colors added gradually, stirring all the time until a homogeneous paste is obtained. The mixture is then to be heated over a water-bath to the temperature of boiling water, and kept at that heat for some time.

Mechanics, Physics, and Chemistry.

CHEMICAL NOTES FROM GERMAN MAGAZINES.

By Prof. Albert R. Leeds.

Detection of Sulphur by Potassium or Sodium.—The sulphur in all inorganic sulphur compounds, whether sulphides, sulphantimonides or sulphates may be detected in the following very convenient way. A small quantity of the pulverised compound is shaken into a thin glass tube fused at one end, a small piece of Potassium dropped upon it, and then some more of the substance to be tested. It is heated until reduction accompanied by ignition takes place, which is almost instantaneously. Potassic or sodic sulphide is formed and makes its presence known by the reddish coating on the side of the tube. When the latter is broken, and moistened with acidified water, sulphydric acid is evolved. By potassium the sulphur in barite, celestite, gypsum, anglesite, ferrous sulphate, magnesic, bisulphate, potassic sulphate, molybdenite, galena, realgar, orpiment, zinkenite, pyrargyrite, etc., can be detected. The sulphur in hair, feather, skin, albumen and other organic bodies may be recognized in the same manner. If it is thought that the quantity of alkaline sulphide is too minute to give a perceptible odor, a moments immersion of that portion of the tube on which the alkaline sulphide has attached itself in a solution of sodic nitroprusside, produces a characteristic violet coloration.

Detection of Phosphorous by Magnesium.—The phosphorous compound freed from water by heating and pulverised, is mixed with 10 milligrammes (in many cases a single milligramme suffices) of magnesium wire cut into small pieces. The mixture is brought into the lower end of a glass tube closed at one end, which is heated until all the magnesium combines with ignition to form magnesic phosphide. When the tube is broken and moistened the odor of phosphuretted hydrogen is plainly discernible. Magnesium is preferable to potassium or sodium because the odor of the burnt naphtha, by which the latter are covered may cloak that of the phosphuretted hydrogen. Magnesium powder is preferable to the wire, not only with organic but also with inorganic substances[*]

[*] Zeitsch. fur Anal. Chem. Erst. Heft. p. 58, 1869.

New Method of Spectrum Analysis.—E. Becquerel has found that when the sparks of an induction coil are made to pass from a saline solution to a platinum wire, the spectra of the substances present declare themselves with far more brilliancy than in the spectrum analyses by the usual way. When the solutions are concentrated the light effects are far more strongly marked, and with chlorine compounds especially they are very bright. In general, the lines are much more numerous than in the usual method, but the characteristic lines are the same.*

Atonic Weight of Lanthanum.—This has hitherto been determined by the amount of baric sulphate, which is precipitated out of Lanthanic sulphate by baric chloride. Marignac and Hermann, among others, have shown that the baric sulphate always carries down with it undecomposed lanthanic sulphate, and consequently the atomic weight of the lanthanum thus determined must be incorrect. H. Zsciesche has found that lanthanic sulphate loses its water at 230°, and by protracted intense white heat in the blast all its sulphuric acid. He also announces a mode of separating lanthanum from didymium so perfect that a thickness of 17 c. m. of the saturated sulphate solution gives no absorption line, while a Gladstone line was given by a solution containing only $\frac{1}{28000}$ of oxide of didymium. He is of the opinion that none of the lanthanum salts previously investigated have been free from didymium. In the determination of the atomic weight, the salts $LaO, SO_3 + {}_3HO$ was heated at first gently and then strongly, until it ceased losing. Thus found, the atomic weight of lanthanum, as given by the mean of six trials, is 45.†

Determination of Lime and its separation from Magnesia in the Analysis of Dolomite.—Calcic oxalate dried at 100°, calcic carb. precipitated out of calcic chloride solution by sodic carb. and Iceland spar, were heated to whiteness by a triple bunsen burner in an Erdmann's oven. At the expiration of half an hour no further loss of weight occurred, and the mass did not effervesce with chlorhydric acid. In the first place the mean of three experiments gave a weight of caustic lime less by 0·07 per cent. than the theoretical, in the second 0·35 per cent less, and in the third 0·27 per cent. more. [As the intensity of the heat is more important for the complete expulsion of the carbonic anhydride than its duration, we have found it better to use a powerful blast lamp. Our own experience has been, that in a platinum crucible heated to intense whiteness for ten minutes, the conversion, in all ordinary cases, is complete.—Translator.] In analyses of dolomite where the calcic carbonate was estimated from the amount of lime obtained by a single precipitation (without a second solution and reprecipitation) the error amounted to 0·62 per cent. excess of calcic carbonate and 0·78 deficit of magnesic carbonate.*

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* Zeitsch. fur Anal. Chem. Erst. Heft. 1869, quoted from Compt. rend. Bd. 66, p. 121.

† Zeit. fur. Anal. Chem. Erst. Heft. p. 110.

Determination of Phosphoric Acid.—E. Kissel, in a long and interesting paper on the different modes of determining phosphoric acid, shows that, 1. By the employment of a quantity of magnesic sulphate, not greater than is requisite for the precipitation, and the addition of a greater quantity of ammonic chloride than is contained in the magnesia-mixture as hitherto prepared, a very small quantity of magnesic hydrate or basic magnesic sulphate is precipitated along with the ammon. magnesic phosphate. 2. That the absence of soluble magnesia salt very much lessens the solubility of the ammon-magnesic phosphate, and so permits a more complete precipitation. 3. That dilute ammonia takes up some of the precipitate, a solution containing ammonic chloride still more. By proper treatment of the precipitate, the presence of a larger quantity of ammonic chloride and employment of not too much magnesia mixture, the co-precipitation of basic magnesia sulphate is diminished or at least reduced to a minimum. On the other hand, portions of ammon-magnesic phosphate on account of its solubility, go into the filtrate and wash water. These little opposing errors effect so entire a compensation, that the results obtained by a single precipitation are satisfactory.†

Spectrum of Beryllium.—G. Klatzo has conducted an investigation upon the question, whether Glucina is constituted according to the formula BeO or Be_2O_3 and decided in favor of the first view, because glucina can take the place of the bases of the magnesia group without alteration of the crystalline form and of the water of crystallization; because the sulphates of glucina heated to 150° retain 1 atom water, which can be replaced by potassic sulphate, and because glucina, like magnesia and zinc oxide, crystallises out of a carbonic acid solution as a neutral salt, which with alkaline carbonates forms a crystalline double salt. He has observed that the spectrum of glucinic chloride gives a red and an intense green line of which the first reaches from 32·5 to 33·, the last from 52· to 52·5 of the scale, when the sodium line coincides with 40.*

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* Dr. Cossa, Zeit. fur. Anal. Chem. p. 141, 1869.

† Zeit. fur. Anal. Chem. p. 164.

Separation of Zinc from Copper.—The method of separation given by A. W. Hofmann for the separation of cadmium and copper may be employed, according to C. C. Wittstein, for the separation of zinc from copper. In the analysis of a lead ore, for example, in which it is required to determine a small amount of tin, copper and zinc, he heats the metallic sulphides which have been precipitated out of an alkaline solution by ammonic sulphide, after the separation of tin and lead in the usual way, for about ¼ of an hour with dilute sulphuric acid. The pure cupric sulphide, which separates out, is collected upon a weighed filter, washed and dried at 100°. The zinc is precipitated out of the hot filtrate with sodic carbonate.†

Mineralogical Notes of German Discoveries.

Preparation of Crystallized Silica Acid in the Dry Way.—G. Rose has conducted the requisite fusions in the fire of a porcelain oven. In the first place microcosmic salt was fused with adularia, three portions of the fused and powdered salt with one portion of powdered adularia, in a crucible of buscuitware. The thoroughly fused mass was treated with dilute hydrochloric acid and placed in a warm position. After some time it dissolved, leaving a snow-white residue. This, under the microscope, was found to consist of transparent six-sided needles only, single or united one to another, which deport themselves in polarized light as uniaxial crystals. Their sp. gr. in one trial was 2·311; the process repeated upon the same material gave 2·317. The silica obtained in this way has all the properties of tridymite, the silica of the form differing from quartz, such as that discovered by von Rath in the druses of the trachyte from Pachuca in Mexico. The sp. gr. of the native tridymite according to three determinations by von Rath is 2·316, 2·312 and 2·295, the two first numbers agreeing closely with those found by Rose for the artificial. When silica was fused with one-third its weight of sodic carbonate, small greyish white, feebly translucent balls were obtained, which had a sp. gr. of 2·373, and were likewise, most probably, tridymite.

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* Zeit. fur. Anal. Chem. p. 202, 1869.

† Ann. der Chem und Pharm. Bd. 115. p. 286, quoted in Zeit. fur Anal. Chem. p. 202, 1869.

Four parts of powdered wollastonite fused in a buscuit crucible in a porcelain oven gave a green glass quite full of tabular crystals which arranged themselves in radial groups, quite after the manner of native tridymite. The similarity of their form, that of six-sided tables, puts beyond a doubt the question of their identity with this substance.

Tridymite is formed, not only through separation out of a flux, but also through strong ignition alone, as well of the amorphous as of the rhombohedral silica. This was shown by H. Rose, as long ago as 1859, that quartz by strong ignition merely, without losing in absolute weight, diminished in specific gravity. Finely powdered rock crystal with a sp. gr. of 2·651 when exposed to the fire of a porcelain furnace, gave a sinter with sp. sg. of 2·329. Amorphous silica, such as is obtained in the analysis of silicates, with a sp. gr. of 2·2, rose on similar treatment to a sp. gr. of 2·311. The same procured by the decomposition of silicic fluoride, gave on ignition to whiteness, a sp. gr. 2·291. Infusorial earth, cleaned with hydrochloric acid and water, from sp. gr. 2·2 rose to sp. gr. 2·303. It is highly probable that all these substances had been converted by ignition into tridymite. From these researches, it appears that the preparation of silica in its three heteromorphic conditions of quartz, tridymite and opal has been effected in the dry way, in the case of the two last only; opal by fusion of silica, tridymite by mere ignition of the same or by its separation out of a flux on cooling.*

Chondrodrite.—Dr. A. Kengott draws the attention of mineralogists to the various analyses which have been made of chondrodrite and humite, and asks that others more exact be made in order that the discrepancies between existing analyses may be reconciled, and satisfactory formulæ arrived at. He shows that when the amount of magnesium sufficient to saturate the fluorine is calculated, and the amount of oxygen corresponding to this per cent. of magnesium is deducted from the various analyses, there results a loss varying from 1·45 to 3·60 per cent. a loss too great to permit the existing analyses to be taken as the ground-work of satisfactory formulæ.†

Smaltite.—A specimen in the Zurich University from Bieber, near Hanau in Hesse, which had lain for a long time among the smaltites, and which indeed had been regarded by superficial observation as smaltite, showed on close examination by Dr. Kengott no tesseral crystals, but the whole mass was made up of rounded figures, which appear to consist of lenticular acuteangled crystals. These globular groups of crystals suggest the globose forms assumed by rhombohedral crystals of siderite or acute rhombohedral or tabular crystals of hæmatite, or certain rosettes of heavy spar. The crystals when complete are obtuse rhombohedra with a basal plane, and the mineral is hexagonal. These rounded masses show in their interior a fine radiate stemlike structure. Before the blowpipe they afford the reaction of arsenic and cobalt. They are consequently to be regarded as hexagonal "einfach arsenic-cobalt," and a renewed examination of the smaltites in our cabinet will probably bring to light other specimens of a similar description. The mineral is accompanied by crystallized heavy spar and isolated quartz crystals.

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* Ber. der. deutsch chem. Gesellsch., Bd. 2. S. 388.

† Vierteljahrsch der Natur for. Gesellsch in Zurich. 1869.

Cutting up Large Iron Shafts.—The Buffalo correspondent of the *New York Tribune* writes: "It is frequently very difficult to break up great shafts of cast iron when necessary to prepare them for the furnace. Old cannon have, therefore, sold low. Upon some, powder and nitro-glycerine have been tried in vain. Some have been burst by ice, others by wedges driven by machinery or long continued hard labor into the muzzle. Here they are cut in two by a continuous stream of molten iron, which wears away the iron as a stream of hot water would eat into a mass of ice. The gun is rolled upon a frame in front of and level with the furnace mouth. Then the muzzle end is shoved in as far as possible among other iron, the opening filled up and luted around the gun, the end of which is melted off. At the next charge it is shoved in another length, and is thus reduced until the breach can finally be rolled in and thus finished without any more expense than with pig or scrap iron.

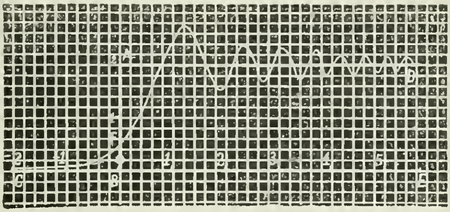
An Eight Ton Steam Hammer.—The Landore Steel Works have erected a single acting steam hammer, the head of which weighs eight tons. The cylinder is thirty inches in diameter. The anvil block, which is cast in one solid piece, weighs seventy-five tons.

ON THE DIFFRACTION PRODUCED BY THE EDGES OF THE MOON.

By Prof. Edward C. Pickering.

In the report of Dr. Curtis on the eclipse of last summer, he describes some experiments tending to show that the brightness seen in the photographs along the moon's limb is caused by diffraction. He adds also a note by President Barnard explaining the same phenomenon geometrically. On the other hand, the experiments of Prof. Morton show pretty conclusively that it is a chemical effect produced in developing the photograph. Moreover, Prof. Smith, although looking carefully for this appearance with a good telescope, was unable to detect it by the eye. The undulatory theory is so well founded that any conclusions derived from it would have great weight; it therefore appeared necessary to examine, critically, the mathematical discussion mentioned above, while the eminence of the physicist who has propounded it, requires that I should give somewhat fully the steps by which I have arrived at quite an opposite result. The argument used by President Barnard is this:—along the edge of the shadow, fringes are formed, alternately bright and dark; but there is a greater increase in brilliancy in the first bright band than diminution in the first dark one, and the same is true of the second, third and of all following it. Hence, he concludes, there is an increase in the total amount of light. Suppose this to be true, and that a luminous point is placed in the centre of a spherical room containing a mirror. We commonly assume that the light cut off from one side is reflected to the other, so that the total illumination is the same as if the mirror was not present. But according to the above theory since diffraction would take place on each edge, both of the mirror's shadow and of the reflected beam, we should obtain an increase of light at all these points. By merely inserting more mirrors we could thus indefinitely increase the illumination, a result quite at variance with the theory of the conservation of forces.

The error, as it seems to me, is that no account is taken of the diminution of light close to the edge of the geometrical shadow. Fresnel computed the intensity of the light at 126 different points, and has represented the results by a sinuous curve E F D, in which abscissas correspond to distances from the geometrical shadow A B, and ordinates to the intensity of the light.* If there was no diffraction the intensity would everywhere equal 2 or A B, and its total quantity would be represented by the rectangle A B E D. The problem then is to compare this area with that included between the curved line and E B C. I have been unable to find any such comparison, and since the formulas are too complex to render an integration possible, I resorted to a measurement of the curve, constructing it on a scale 20 times that of the above figure. The part



B F C corresponds to the light which is inflected or bent within the shadow, and has B C for an asymptote. The area of the part within the limits discussed by Fresnel, that is from 0 to — 5·5 can be obtained with a good deal of accuracy, and gives the result ·300; but beyond this we have a space whose height on the above scale nowhere exceeds one thousandth of an inch, but whose area might be very considerable, since its length is indefinitely great. To determine this area, at least approximately, I devised the following method which I hope may be found useful in many similar cases. Let $y' = f(x')$ be the equation of the curve of which we only know a limited number of values of x' and y'. Make $x'' = \frac{1}{x'}$ and construct the points whose coordinates are x'' and y'. Draw a smooth curve through them and the origin, since when $x' = \propto$, $a'' = 0$, and $y' = 0$, and we shall have between 1 and 0 a curve corresponding to any values of x' between 1 and $\propto$. From this we can obtain approximate values of y' for any value of x' however great. Again, let A represent the area included between the axis of Y and any ordinate y'. Now construct a curve in which $y'' =$ A, and $x'' = \frac{1}{x'}$ as before.

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*This curve is not given in the original memoir of Fresnel, but being found among his manuscripts has recently been published. *Œuvres complètes d'Augustin Fresnel*, Vol. I. p. 382. The figure of this curve in Billet's *Traité d'Optique Physique*, Vol. I. Plate II. is very incorrect, F B being made equal to 1 instead of ·5

If we prolong this curve until it meets the axis of Y we obtain a value of A or the total area corresponding to $x''=0$ or $x'=\infty$, that is, the whole space included between the curve and its asymptote. Applying this method to the present case the total area of B E F was found to be ·32, ·35 and ·33, the last measure being the most reliable. The great variations are due to the fact that no values of x' greater than 5·5 could be obtained.

To determine the area of F D E B the parts above and below the line A D were compared by dividing them up into triangles, by cutting them out of sheet lead and weighing them, and by Simpson's rule applied to the ordinates of the curve, also directly to the numbers computed by Fresnel. The third and fourth methods appear most reliable, but all gave the part below the line *greater* than those above. The excess by the third method was ·355 : ·348 : ·350 : ·344 : according as the calculation was limited by the middle of an elevation or depression. The fourth method, in the same way, gave ·337 : ·334 : ·345 : ·345. Instead of an increase we therefore have a diminution of light, which is evidently due to the portion F C′ B which is inflected. Allowing for this, we have the area of the rectangle equal 11·000, that of the curved area 10·984, leaving still a deficiency of ·016, but this very small difference is easily accounted for by errors of measurement. Fresnel's numbers, moreover, do not seem to be perfectly accurate, for it will be found that the magnitudes of his maxima and minima do not diminish with perfect regularity.

Let us next see what excess of light would be needed to produce the effects observed in the photographs. A measurement of the band of light shows that its brightest part is at least one seventieth of the moon's diameter in width, or thirty miles. The unit of Fresnel in this case would be about 35 feet, hence the light received on this portion would be represented by a rectangle with base 4500 and altitude 2, or area 9000 units. If the excess then equalled the whole of the first bright diffraction band or ·6 it would only increase the brightness of the sun's disk by one fifteen thousandth. While the small difference obtained in my computation would only equal one five thousandth of one per cent. Evidently then there can be no appreciable effect due to diffraction.

Massachusetts Institute of Technology, March, 1870.

MAGNESIUM AND ELECTRIC LIGHTS AS APPLIED TO PHOTO-MICROGRAPHY.

By Brevet Lieutenant Colonel J. J. Woodward,
Assistant Surgeon, U. S. Army.

Army Medical Museum, Microscopical Section,
January 4, 1870.

Brevet Major General J. K. Barnes,
Surgeon General U. S. Army.

General :—I have the honor to inform you that on the 25th of October last, I began to conduct in person a series of experiments, intended to devise means for escaping certain difficulties which had hitherto prevented the successful preparation of Photo-micrographs of specimens, selected from the valuable and daily increasing series of permanently mounted microscopic sections of normal and pathological tissues, which form so interesting a portion of the treasures of the Museum. In these experiments I used the sun as a source of illumination, and following the process which I had described in full elsewhere,* I had no difficulty in arranging a method, by the aid of which this class of objects could be photographed quite as successfully and readily as the diatoms and other test objects which had previously been so satisfactorily reproduced in this section of the Museum. I shall take occasion in the course of a few days to lay before you prints of some of the tissue-preparations thus produced. At present it is my desire to call your attention to certain important observations which I had the good fortune to make, while my experiments were in progress, and which it appears to me cannot fail to be of interest and service to all microscopists.

During the last week of October and the first two weeks of November, I relied wholly on the sun as the source of illumination for producing negatives. In this period, during which I had but two perfectly cloudless working days, and several fractional days, on which my work was continually interrupted by passing clouds, I had ample opportunity to convince myself that the uncertainty of the weather was a most serious hindrance to the preparation of successful photographs of microscopic objects, and I ceased to wonder that European microscopists, who are exposed to a climate even more variable than our own, have not yet succeeded in placing the art of Photo-micrography upon such a basis, as to make it a convenient and habitual auxiliary in all microscopal investigations. This desirable end I believe I have attained; but it has been by resorting to artificial lights and thus making the success of the process wholly independent of the weather.

On the 12th of November I commenced a series of experiments with artificial lights which were most fortunately crowned with success, both the Magnesium and the Electric lights proving adequate sources of illumination for the production of Photo-micrographs even with the highest powers.

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* Circular No. 6, War Department, Surgeon General's Office, Nov. 1, 1865, page 148, *et. seq.* American Journal of Science and Arts, Vol. XLII, Sept. 1866.

For the production of the Electric light I used a Duboscq's lamp, set in motion by a battery of fifty small Groves' elements. I found that with this source of light, photographs could be successfully taken with any power with which pictures can be taken by sunlight; and I was delighted to find, as I had anticipated, that the very exaggeration of light and shadow which has prevented the Electric light from being generally adopted as a source of illumination in the preparation of photographs of the size of the object, or smaller, proved of immense advantage in the reproduction of the feeble microscopical images of highly magnified objects, and that the pictures were hence clearer and better defined than any photographs of similar objects I had hitherto seen produced by sunlight. I found also that the Electric light was so much more manageable than sunlight as a source of microscopic illumination, that I could readily arrange it to produce negatives with much shorter exposures than are indispensable with the sun.

The Magnesium light shared these qualities to a high degree, but I found that its best work was done when the object was not to be magnified more than a thousand diameters, and that there were certain limitations to its use on test objects which will be referred to in the sequel.

With one or the other of these artificial lights as a source of illumination, I have prepared a considerable number of negatives of interesting microscopical objects, of which a few are appended to this report by way of illustration, while the others will be laid before you in future reports on special subjects.

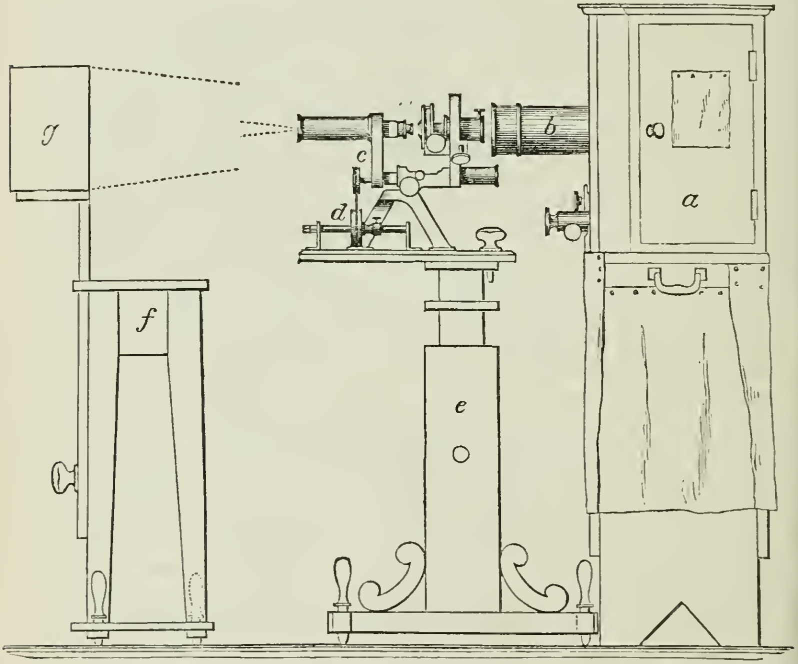
The Magnesium and Electric lights are mentioned as possible sources of illumination for the production of Photo-micrographs by Dr. Lionel Beale, in the fourth edition of his "How to work with the Microscope," page 275. I am not aware, however, that any one has made successful negatives with high powers with either of these lights prior to the experiments here recorded. There are in the Museum a few photographs with low powers taken with the Magnesium light by Dr. C. F. Crehore, of Boston, Mass., who kindly presented them August 3, 1866. Negative No. 90, old Microscopical series, Army Medical Museum, represents a few villi from the small intestine of a mouse, photographed by the Electric light with a 4-10th objective of Wales arranged to magnify 84 diameters. The Electric light was produced by 40 Bunsen's cells, and as I had no Electric lamp at the time, I held the carbon points in two retort holders and managed as best I could, during the exposure, the uncertain light thus produced. I know of no other Photo-micrographs than the above to have been actually made by the Electric or the Magnesium lights; certainly if any have been, they have not been sufficiently successful for their authors to be willing to give them any degree of publicity. I have no hesitation, therefore, in claiming for the Museum and for myself the credit of having demonstrated the serviceable character of these lights as sources of illumination for the preparation of negatives with high powers, and of having devised a simple method which brings their use within the reach of every microscopist.

I propose now to sketch briefly the process by which negatives of microscopic objects can be conveniently produced with these artificial lights.

1. The Electric light is by far the best of all artificial lights for the production of Photo-micrographs, and when used as I am now about to describe it, it is both convenient and economical. I use a Grove's battery of fifty elements. The battery is placed just outside of the operating room in a closet from which the fumes escape through an earthen pipe into the main chimney of the building. This battery was furnished by Mr. William Ladd, Nos. 11 and 12 Beck Street, Regent Street, London, W. The rubber cups are 4¾ inches high, 3¼ wide and 2 thick. The platinums are 5½ inches by 2⅛, and weigh about 60 grains each. The zincs are bent on themselves so as to present a part of their surface on each side of the platinums, and weigh, when new, about a pound apiece. Mr. Ladd furnishes these batteries in trays of ten elements, at five pounds sterling per tray, and I find that a battery of five trays is sufficient for most purposes. Seven pounds and a-half of strong commercial nitric acid, and three of sulphuric, diluted with ten times the quantity of water, is sufficient to charge this battery, which will then produce the light continuously for from three to four hours. The cost of running the battery for this time, including in the estimate the amount of zinc consumed, and the cost of amalgamating every third or fourth time of using, is very moderate. I make it a practice to have the battery washed out, the acids thrown away and the porous cups put to soak immediately after I have done the day's work, and all this is so simple that I have had no difficulty in instructing an orderly to do it, so that the management of the battery does not occupy any part of my time.

The Duboscq's lamp, the microscope and the plate holder are arranged in a dark room which enables me to dispense with the use of a camera. The general arrangement of the apparatus is shown in the cut.

The Electric lamp of Duboscq (*a*) is placed on a stool against the wall at one end of the room, and its light concentrated by a pair of condensing lenses (*b*) on the lower lens of the achromatic condenser of the microscope. The microscope (*c*) (a large Powell and Lealand's stand) is placed on a small table (*e*) which is so arranged that it can be lowered or elevated at pleasure and can be levelled by means of three levelling screws at its base. The plate holder (*g*), also arranged so that it can be raised or lowered at pleasure, is supported by a small table (*f*) which stands on three levelling screws. The floor of the apartment is quite level. The lenses employed for the microscope are those of Mr. William Wales of Fort Lee, New Jersey, specially constructed for bringing the actinic rays to a focus. For powers above the ⅛th, however, I have found that the achromatic objectives of Messrs. Powell and Lealand, of London, answer an excellent purpose, and indeed that their immersion 1-16th exceeds in defining power any objective which has as yet come under my notice.



In taking photographs with this apparatus, I proceed as follows: The Electric lamp being set in motion, the table holding the microscope (which has previously been levelled,) is raised or lowered and moved from side to side till the centre of the achromatic condenser is brought to the centre of the illuminating pencil proceeding from the lamp; the object is then placed on the stage and carefully adjusted. A cell of plate glass containing a saturated solution of the ammonio-sulphate of copper is fixed just below the achromatic condenser, and not only prevents the admission of non-actinic rays, but excludes the very great heat which accompanies the Electric light, and also moderates its effect upon the eye of the observer.

The light thus produced is very agreeable to the eye, and I find myself able to work with it from four to five hours without fatigue. It has also the advantage that all the colors of the objects examined disappear, and the preparation appears black on an azure field which resembles the sky on a clear day, so that the observer sees at a glance how the object will appear in the photograph (in which the same black lines or tints will be faithfully reproduced on a white field) and is thus enabled to arrange his achromatic condenser and other adjustments so as to produce the most satisfactory effect.

Everything having been arranged at the microscope to the satisfaction of the observer, the eyepiece is taken out, and, the image allowed to fall on the ground glass of the plate holder, which has previously been placed at the distance necessary to give the magnifying power desired with the objective employed. The operator adjusts the plate holder to the right height and sees that it is perpendicular to the optical axis of the microscope, which he readily does by observing that all parts of the field are equally in focus. He then takes out the ground glass and finishes the fine adjustment with a sheet of plate glass and a focussing glass, after which the sensitive plate is inserted, the exposure made and the operation is finished.

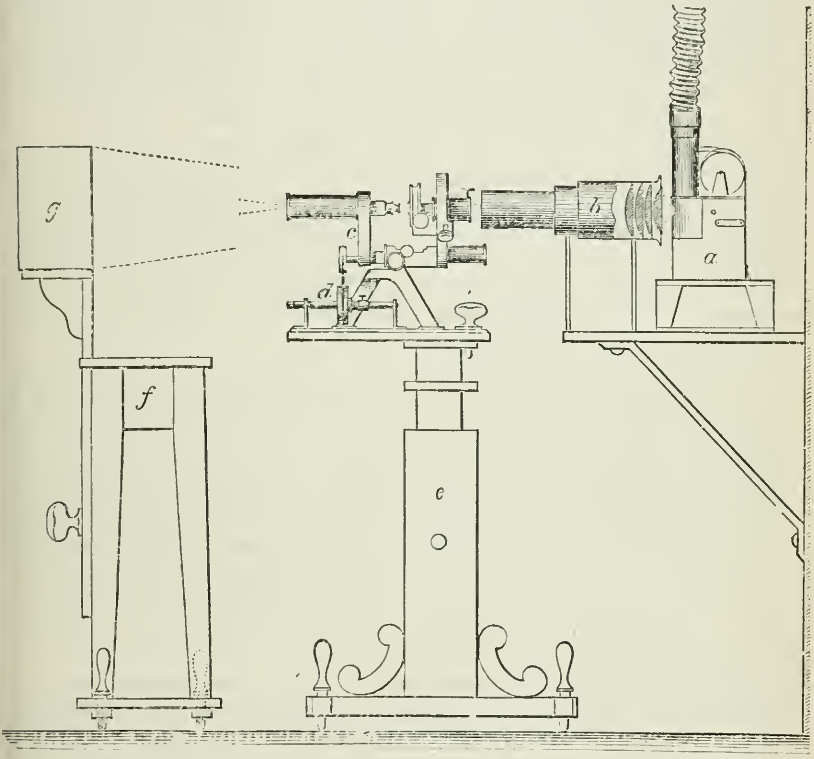
To enable the observer to focus the microscope while sitting at a distance from it at the sensitive plate, the following contrivance is employed. On the table which supports the microscope (*e*) two brass shoulders, each two inches high, are screwed. Through these runs an iron rod nine inches long, on which slips a brass pulley (*d*) which can be clamped at any point. A cord connects this pulley with the wheel of the fine adjustment of the microscope which is grooved for the purpose. It is evident that whenever this iron rod is turned, the pulley turning with it will move the fine adjustment of the microscope. To effect this, the iron rod terminates in a square extremity, so that a joint of an ordinary fishing rod, to which a brass ferrule, shaped like a watch key, has been rivetted, enables the operator to focus the microscope at any ordinary distance. When greater distances are required two joints of the rod may be used. The rod, being graduated into feet and inches, enables the operator to record the distance employed for each picture. When the focussing is completed, the rod is removed. I have found this simple and cheap arrangement superior in delicacy and convenience to any of the more costly arrangements, I have heretofore tried.

The chemical processes, employed in taking the negatives, do not differ in any respect from those used in ordinary photographic work, and I have found that by employing a practical photographer, allowing him to manage the dark room and confining my whole attention to the optical arrangements, I not only get many times more pictures in a day but they are much better than can be produced by any one who attempts to do the photographic work, as well as manage the microscope himself.

I find myself thus enabled to sit down quietly of an evening, and during four hours work to produce from twelve to thirty negatives or more, in accordance with the difficulty of the subjects and my previous knowledge of them. Any microscopist who is willing to go to the moderate expense of battery and lamp, and to add two or three specially constructed objectives to his microscopical apparatus, can, by employing a photographer one or two evenings in the month reproduce all the more interesting of his month's observations with a degree of economy and beauty not to be obtained by any other means, and if he follows the method I have above described, the character of his results will be conditioned by his skill as a microscopist rather than by any other circumstance. As to the time of exposure required for taking negatives with the Electric light, I find that for one thousand diameters about thirty seconds are necessary for that class of objects, (such as Angulatum, the Nobert's plate, &c.,) for which it is not necessary to employ a ground glass plate to prevent interference phenomena. In photographing the soft tissues and many other objects, it is necessary to insert a piece of ground glass below the achromatic condenser to escape the interference phenomena which else occur, precisely as must be done in photographing the same objects by sunlight. This increases the time of exposure to about three minutes for one thousand diameters. Other powers require proportional times.

2. The Magnesium light affords a beautiful source of illumination comparable to white cloud illumination of the best character, or to the light of the sun after it has passed through a sheet of ground glass. Without the use of ground glass, this light serves admirably for the production of photographs of the soft tissues with any power under a thousand diameters. The light being composed of a mixed pencil, with rays passing in all directions, there are no interference phenomena, but for the same reason, on the Nobert's plate and many test objects, the results are inferior to those produced by the sun or by the Electric light; with powers much higher than a thousand diameters, however, the time of exposure becomes inconveniently long.

The process employed by me in the production of negatives with the Magnesium light, is essentially the same as I have above described for the Electric light, simply the Magnesium lamp is substituted for the Electric, and the condenser of an ordinary Oxy-calcium Magic Lantern is made to concentrate the light on the achromatic condenser of the microscope. The cut represents the arrangement. The Magnesium lamp (*a*) stands on a shelf fastened against the wall. The condenser (*b*) concentrates the light on the lower lens of the achromatic condenser of the microscope (*c*) which stands on a table (*e*) supported on three levelling screws. The image received on the plate holder (*g*), which is supported on a table (*f*) is photographed precisely as in the case of the Electric light as above described. The same focussing apparatus (*d*) is employed and the ammonio-sulphate cell should invariably be inserted, but the ground glass is never necessary. I find that it requires exposures of about three minutes to produce negatives of tissue-preparations with five hundred diameters. Other powers require proportionate exposures.



The Magnesium lamp used by me for this purpose was the two-ribbon lamp of the American Magnesium Company, (No. 2 Liberty Square, Boston, Mass.,) sold by that company for Magic Lantern purposes, price $50. The ribbon weighs about 52 centigrammes per metre, and is sold at $2.50 per ounce. Two ounces will, with care, answer for three or four hours constant work, and ought to produce from twelve to thirty negatives in accordance with the difficulties of the subject to be represented. The fumes of Magnesia resulting from the combustion are carried into a chimney five feet long, made of a spiral wire covered with muslin, which terminates in a muslin bag in which the oxide condenses, while the draft goes on through the interstices of the muslin. The chimney and bag are furnished by the Company for $2.50.

In commenting on the above processes it may be remarked that for the anatomist and physiological investigator, the Magnesium lamp affords a satisfactory and sufficient source of light for the photography of normal and pathological tissue-preparations. The same end can be equally well or even better attained with the Electric lamp, with which also the most difficult test objects can be satisfactorily reproduced. Where economy of apparatus is the object, the Magnesium lamp will be preferred by ordinary workers; but where much work is to be done, the high price of the Magnesium ribbon more than counterbalances the cheapness of the apparatus, and the Electric light becomes the most economical. For the information of any practical photographers who may be employed for work of this character, I may add the following remarks on the chemical process employed in the production of the negatives from which the appended prints were made. An ammonium and potassium portrait collodion, rich in alcohol, was employed, developed with the ordinary solution of iron, and fixed with cyanide of potassium. Where it was necessary to intensify, the hydro-sulphuret of ammonium was resorted to.

In illustration of the character of these sources of illumination as compared with each other and with sunlight, I herewith append three prints from negatives, taken with a Wales' inch and a half, from the 6th square of a Möllier's diatom type-plate, specially prepared for the Army Medical Museum by that skillful microscopist. The first, from Negative 79 (new series), was taken by sunlight, with 40 diameters; in the second, from Negative 123 (new series), the Magnesium light was used, and every thing else remaining the same, the distance was increased so as to give 48 diameters; in the third, Negative 158 (new series), the Electric lamp was employed, and every thing else still remaining unaltered, the distance was increased so as to give 66 diameters. It will be understood at once, that on account of the increase of distance, the second picture would have been slightly less sharp than the first, and the third than the second, had precisely the same source of light been employed; nevertheless, in spite of this disadvantage, to which they were purposely exposed, the Magnesium and Electric pictures are far superior to that taken by sunlight, and of the two the Electric is much the best. It is especially to be observed, that in the Electric picture the contrast obtained is so great that the objects appear clearly defined on an almost perfectly white ground, which is never the case with the Photo-micrographs taken with the sun as a source of illumination.

As a further illustration of the capabilities of the Magnesium and Electric lights, I add a few photographs taken by each.

BY THE MAGNESIUM LIGHT.

Arachnoidiscus Ehrenbergii. Magnified 400 diameters, by Wales' ⅛th. Negative 114 (new series).

Small vein and capillaries, from the muscular coat of the urinary bladder of the frog. Magnified 400 diameters, by Wales' ⅛th. Negative 103 (new series). This Negative is taken from preparation No. 3378, Microscopical Series, in which the bladder was injected with a half per cent. solution of nitrate of silver, and subsequently stained with carmine dissolved in borax. The epithelium was then brushed off with a camel's hair pencil, and the preparation transferred through absolute alcohol to canada balsam; the photograph reproduces every thing but the color.

BY THE ELECTRIC LIGHT.

Pleurostaurum Acutum. Magnified 340 Diameters, by Wales' ⅛th. Negative 109 (new series).

Triceratium Favus. Magnified 340 Diameters, by Wales' ⅛th. Negative 110 (new series).

Navicula Spima. Magnified 840 diameters, by Powell and Lealand's immersion 1-16th. Negative 112 (new series).

Human red blood corpuscles. Magnified 1,000 diameters by Powell and Lealand's immersion 1-16th. Negative 145 (new series).

Section of an epithelial cancer of the larynx. Magnified 400 diameters, by Wales' ⅛th. Negative 162 (new series). This Negative is taken from preparation No. 2277, Microscopical Section. The print shows the nuclei and cells of the growth with great distinctness.

Grammatophora Marina. Magnified 2,500 diameters, by Powell and Lealand's immersion 1-16th. Negative 151 (new series).

I have the honor to be, General,

Very respectfully, your obedient servant,

J. J. WOODWARD,

Assistant Surgeon and Brevet Lieutenant Colonel, U. S. A., in charge of the Record and Pension Division, and of the Medical, Microscopical and Comparative Anatomy Sections of the Army Medical Museum.

NOTE.—Since the foregoing essay was printed, I have obtained a number of excellent pictures, with power ranging from 400 to 1,000 diameters, by using the ordinary oxycalcium light as the source of illumination. Some of these pictures were not inferior to the best work I have done with the magnesium light, the process employed was the same, and the times of exposure did not materially differ. I will contribute full details in a short time.

J. J. WOODWARD.

JARGONIUM IN FACT A COMPOUND OF URANIUM.

THERE was published in Vol. LVII., page 401 of this *Journal*, a communication from Mr. H. C. Sorby, F. R. S., upon the presence in the spectrum of some zircons, of numerous and very striking absorption *lines*, which could not, at the time, be referred to any known substance, and which were, therefore, ascribed by their discoverer to be "due to an elementary substance not hitherto recognized." To this supposed new earth, which was believed to be closely allied to zirconia, the name Jargonia was proposed.

The following extract from a paper by the same writer, which has just appeared in the *Chemical News*, places the subject in an entirely different light.

> When a scientific man has been led into an error, and afterwards discovers his mistake, I think it a matter of duty that he should take an early opportunity to correct it. I, therefore, now write the following notice of certain remarkable peculiarities in the spectra of some compounds of the oxides of uranium with zirconia, which led both myself and others* to conclude that they were due to a new elementary source.
>
> Though the spectra of the different salts of those bases which show well-marked absorption-bands often differ in detail, yet they usually resemble each other so much that there is no difficulty in recognizing each particular element. This is so constantly the case in the various compounds of erbium, didymiun, and cobalt and in the ordinary salts of uranium, that, for a long time, the more I studied this question, the more did it appear to be a genera rule; and there seemed to be no reason to suspect that a few specia compounds of uranium would give spectra with absorption-band as unlike as possible those of all others. Such, however, turns ou to be the fact, when its oxides are combined with zirconia.
>
> As an excellent illustration of important differences in mere detail, but general correspondence, I would refer to the spectra o didymium in different states of combination,† and would especiall refer to the most distinct of the numerous absorption-bands, which occurs in the yellow. The various compounds agree in showin this band in the same general position; but, by careful management, and by the use of sufficient dispersive power, it may be resolved into a very variable number of narrow bands or black lines
>
> The remarkable spectrum of some jargons has been already described by me in the *Chemical News* (vol. xix., p. 122) and in th

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* Professor Church's paper, *Chemical News*, vol. xix. page 121, and Professo Loew, vol. xx. page 9.

† See also Bunsen's paper, *Pogg. Ann.* vol. cxxviii., p. 100.

Proceedings of the Royal Society (vol. xvii., p. 511.) One of its most striking peculiarities is that, when light passes in a direction perpendicular to the principal axis of the crystal and the spectrum is divided by means of a double-image prism into two spectra having the light polarised in opposite planes, though some of the absorption bands are of equal intensity in both images, yet others are comparatively absent, some in one and some in the other; whereas, in the case of other dichroic crystals which give spectra with absorption-bands, they are usually all more distinct in one image than when the light is not polarised, and all fainter, or even comparatively absent, in the other. No sooner had I observed this spectrum than I made various experiments in order to ascertain whether uranium was present or not; and the then known tests that could be applied to the amount of material at my command seemed to show that it was absent. This was quite in accord with the results of the various analyses published by other chemists, none of which mention the existence of any trace of that substance. Moreover, the general character of the spectrum was entirely unlike that of all the known compounds or uranic acid. The various artificial salts all agree in giving a variable but small number of moderately broad absorption-bands in the blue end; and the same is also seen in the case of several natural minerals; whereas the jargon gave a most unusually large number of narrow black lines (fourteen quite distinct, besides others more faint and a single broader band which I cannot separate into lines,) extending from the red end; so that nearly all occur in that part of the spectrum which is entirely free from bands in all previously known compounds of uranic oxide. This same general fact was also seen in the spectrum of the opaque blowpipe beads gently flamed, as described in my former paper.

I will not enter into a description of the various chemical and physical facts which seemed to warrant the conclusion that zircons sometimes contains a new earth; but, taking these into consideration, there seemed to be every reason to believe that spectra which thus differed so much from those of any previously known substance were characteristic of this new earth. Judging from the facts then known, it was more probable that spectra of such a new type were due to a new element than that they were due merely to a combination of two such elements as zirconium and uranium.

In studying the spectra of crystalline blowpipe beads, it seemed desirable to examine those made with carbonate of soda, with or without a little borax. This, when melted, dissolves certain oxides; and, though it crystallises on cooling, so as to be only partially translucent, yet, with strong direct sunlight, well-marked spectra may be seen.

In examining the various products into which I separated jargons in order to study the supposed new earth in a state of purity, I obtained a small quantity of a dark colored substance (apparently zirconia) containing some oxide, which communicated a green tint to a glassy borax blowpipe bead, but yet not sufficiently distinct to show that it was due to uranous oxide. I therefore thought that the carbonate of soda method might throw light on the question; and, though the presence of zirconia prevented solution by pure carbonate of soda, the addition of a little borax enabled me to prove that uranic oxide is really present in some jargons. Such then being the case, it seemed desirable to ascertain whether the oxides of uranium would give rise to any special spectra when present along with zirconia in crystalline blow-pipe beads. To my astonishment, I found that the spectra were precisely the same as those obtained in the case of what I had thought to be an approximately pure new earth. When, however, I had ascertained the quantity of oxide requisite to give this result, I was no longer surprised that I had suspected its presence. In the case of transparent blowpipe beads of borax with microcosmic salt, it is requisite to have as much as 1-50th grain of uranous oxide to show faintly the characteristic absorption-bands; whereas, when present along with zirconia in the crystalline beads, 1-50,000th grain gives an equally well marked spectrum; and 1-2000th grain shows it far better than a larger quantity, which makes the beads too opaque. These very minute quantities were obtained by the repeated division of a small known weight, either before or after fusion with borax. This spectrum also differs very considerably from the spectra of the usual salts or blowpipe beads of uranous oxide.

The oxide of uranium is so easily reduced at a high temperature to the state of protoxide in a borax bead with excess of boric acid, and is so readily peroxidised at a dull red heat when crystallised along with borate of zirconia, that there seemed good reason to refer the change in the spectra to temperature rather than to the state of oxidisation, until after it was found that they were due to uranium. By gently flaming the crystalline bead, the spectrum is entirely altered to that which seems to be characteristic of the compound of borate of zirconia with uranic oxide. This shows a spectrum with five well marked absorption-bands, all of which occur at the red end, where there is no trace of bands in the case of the ordinary compounds of uranic acid. I have tried many experiments in order to ascertain whether any other element besides zirconia will cause uranium to give similar abnormal spectra; but none show anything of the kind—at all events in similar conditions. A few have special characters, as described below; but the majority exert little or no influence; and even when the blowpipe beads are crystalline, they show only the usual spectra of the oxides of uranium. Moreover, no such great change in the character of the spectra of any other elements which give absorption-bands is to be seen when they are combined with zirconia; and, as far as my present experience goes, it seems as if such very abnormal spectra were met with only in the case of these remarkable compounds of zirconia with the oxides of uranium.

Such, then, being the facts, it appears to me that we are now in a position to explain why certain zircons give three different spectra as described in my former paper. Some jargons (usually those of a green tint) contain a little uranium so combined that the characteristic spectrum is only faintly visible; whereas, after ignition, the intensity of the absorption-bands is permanently increased to a variable extent, occasionally only a little, but, in some cases, as much as twenty-five times. This more powerful action on light is accompanied by an increase in hardness and in specific gravity (sometimes as much as from 4·20 to 4·60,) as described in my former paper; and I have since found that these changes are approximately proportional to the amount of uranic oxide in the various specimens, as shown by comparing the spectra of the blowpipe beads. This change may partly depend on the oxidisation of the uranous oxide, since some specimens slightly increase in weight when ignited; but I think it cannot be mainly due to that, for sometimes there is no such increase; and uranous oxide, combined with zirconia, gives rise, not to a spectrum without bands, but to one with several of very marked character, as described below. On the whole, since this abnormal type of spectrum is so characteristic of combination with zirconia, it appears to me more propable that the effect of a high temperature is to cause the uranic oxide to combine more specially with the zirconia, as though the greater part existed naturally as a silicate, but after ignition as a zirconiate. We may also apply the same explanation in the case of zircons more or less strongly colored by other oxides, which become almost colorless when heated; and thus this unexplained peculiarity of zircons may depend on the fact of zirconia being able to play the part of both a base and an acid, which, as compared with silica, has an affinity for bases varying according to the temperature.

The brown-red zircon, from Ceylon (named at page 514 of my paper, kindly presented to me by Mr. E. L. Mitford, of Rusthall) gives a spectrum precisely like that of the borax blowpipe beads crystallised after treatment in the deoxidising flame, and, therefore, no doubt contains uranous oxide. This spectrum being given by only one part of the crystal, probably depended upon the presence of some substance which either reduced the uranic oxide or prevented the oxidisation of the uranous.

These facts thus clearly show that the various spectra which seemed to indicate the presence of a new element existing in three different physical conditions are, in reality, only characteristic of the two oxides of uranium, combined with zirconia or not in combination. Perhaps some may think that my having been thus led astray shows that little or no reliance can be placed on the method of investigation employed; but I contend that the mistake was due to its being such an unexpectedly delicate test for uranium; and as explained above, the error was ultimately corrected by a further development of the same method. As far as the interests of science are concerned, there is no need to regret the general result. We have lost what appeared to be good evidence of a new earth, but have gained an almost entirely new system of blowpipe testing, which enables us to detect such a minute quantity of some substances as could not be recognised by the ordinary means.

Coal and Smoke Consumption.—On the Pennsylvania Railroad, experiments are now being made, says the *Chicago Railroad Review*, with an apparatus for bituminous coal invented by J. T. Rich, of Philadelphia, who puts into the fire box a "dead plate" extending from side to side, sloping from a short distance beneath the door and then turning down perpendicularly to the grate bars. Above is a fire brick arch extending from the back well forward, around which the ascending flame must pass toward the front. Outside the door is a hopper, constantly supplied with coal, which passes in, as that already in the fire-box works down to the dead plate. A fire being started in the grate, cokes the coal on the dead plate; and the heat is utilized by passing around the arch and through the flues. As the coke, thus made, burns away, its heat and gases, without smoke, passing through the flues, new coal constantly works down and undergoes the same process. The experiment thus far shows there is no doubt that the process will result in almost entire freedom from smoke; but the practical question, whether steam can be made fast enough, is not yet decided.

The Southern Phosphate Tract.—The famous beds of phosphate of lime, near Charleston, S. C., are eighteen inches or two feet thick; the phosphate is worth in Charleston $6 a ton for fertilizing purposes. It is proposed to construct a canal fifty feet wide, three feet deep, and two miles and a quarter long, extending from the phosphate beds to Ashley River, so that the material can be boated down to the city.

Copper Smiths are Free from Cholera.—From the observations of Drs. Burg and Clapton, as it would seem, copper workers get green stains upon the gums above the teeth, and their perspiration is of a bluish green hue, but this seems to bring them no specific disease, and saves them from the above disorder.

Bibliographical Notices.

The Tehuantepec Railway; its Location, Features and Advantages under the La Sere Grant of 1869. D. Appleton & Co.

In the introduction to this interesting work, Mr. Stevens, the President of the Company, calls attention to the fact that in October of the year 1867, a grant was made by the government of Mexico for 70 years, of large tracts of land, to a company to be formed by Don Emilio La Sere, to open inter-oceanic communication across the Isthmus of Tehuantepec by railroad, carriage-road and telegraph line. It is to be free from all taxation or imposts of any kind by the government, except the payment of eight per cent. of the net profits of the enterprise, whenever dividends shall be declared for the stockholders, and twelve cents for each through passenger. Such a company has been duly organized, and the general plan of the road has been submitted to and obtained the approval of the Mexican government. It is well known to readers of history, that Columbus was animated in all his voyages by the belief that the shortest route to the gold and spices of the Indies lay toward the West. Though Columbus died without finding the short passage he so eagerly sought for, his object remained prominent to successive navigators, and in the second part of the work under consideration, written by Mr. Henry Stevens, a very interesting historical sketch is given of the various expeditions which were fitted out by Spain, Portugal, and England, with this object more or less remotely in view. Though unsuccessful in finding a passage, they made known the entire coast of North and South America. At last, in 1519, the way was found, and the Sadrones, Philippines, and the long sought for Moluccus were obtained by Magellan, but alas, the passage was so cold, so stormy and so far to the southward, as to be of inferior value to commerce. Perceiving the necessity of a direct communication, "all the five routes from Darien to Tehuantepec were spoken of then as now, with the view of constructing immediately a canal, road or portage, deeming it safer to transport goods than to carry them round the strait." The far-sighted Cortes, the conqueror of the mighty empire of Montezuma, apprehended the advantages of the Tehuantepec route and procured immense tracts of land along its course to be confirmed to him by deed of the emperor, Charles V. The line of the projected Railway stretches from Minatitlan on the east to the bay of Ventosa on the west coast, a distance of about 162 miles. The summit level is the pass of Masahua, 793 feet above tide-level in Ventosa bay. The steepest gradient is 60 feet per mile. The road occupies a depression in the plateau of the Cordilleras, and owing to the great elevation of these table-lands to the northward, and its less tropical position, the climate of the Tehuantepec route is said to be milder and more salubrious than that of Darien. The granitic axis of the central ridge is flanked by slates, primitive limestones and sandstones; good building stones are abundant, and rich deposits of iron, tin, silver and gold are reported from various localities. Other chapters on the vegetable productions, population, towns, domestic industry and scenery will be found interesting by any one who is curious to learn more of this country, hitherto little known, but daily more spoken of and written about.

Agricultural Qualitative and Quantitative Chemical Analysis. By Prof. G. C. Caldwell. Orange, Judd & Co.

The author says, in his preface, that the book is meant to be a complete manual of chemical analysis as applied to agriculture. "The qualitative and quantitative processes that are described refer only to such substances as are found in soils, plants, animals, fertilizers, or other materials or other products of agriculture, and moreover, in order to reduce the size and consequently the cost of the book as much as possible, except in two or three instances, only those methods of analysis are introduced which are most commonly used by good chemists, and have been tried and found reliable, with such improvements as have been made in more recent practice." This is attempting a great deal in a small octavo volume of less than 300 pages, and an examination of the contents of the book, shows that brevity has been obtained at a sacrifice of that minute and detailed description of apparatus and processes, which is one of the most essential requirements of a laboratory handbook. The directions given in chapter I, for preparing and testing the reagents, are too meagre and concise to satisfy the beginner, and he will be compelled to resort to the work of Fresenius from which they have been condensed. To condense a treatise on analytical chemistry by omission of the minutiæ on which success depends, and indicate only the principles of the analytical process, is to deprive it, in a great part, of its usefulness. The same remark applies to the methods given for the determination of specific gravity, for solution, evaporation, filtration, weighing of precipitates, etc. Also to the chapters on the reactions and methods of quantitative estimation and on special methods of analysis. It is greatly to be regretted that the student is not referred to Fresenius for all these matters, and the space thus gained devoted to agricultural chemistry proper. The student might thus have been made acquainted with the contents of all the important contributions to this branch which have been made of late years in English, French, and especially in German periodicals not generally accessible, and the labor of research and selection have been accomplished once for all by the author. As it is the reader must consult the original memoirs.

Fresenius' Quantitative Chemical Analysis. Edited by Prof. S. W. Johnson. John Wiley & Son.

The drawing and description of Rumpf's azometer, which are given in this edition, together with Dietrich's tables of the absorption of Nitrogen in Bromized Sodic Hypochlorite and of the weights of a cubic centimetre of Nitrogen for different temperatures will greatly facilitate the estimation of Nitrogen by expulsion in the wet way. The processes given in Fresenius for the volumetric determination of Ferric Oxide by Stannous Chloride, by Sodic Hyposulphite and Potassic Iodide, by Fuch's method of boiling with weighed strips of metallic copper, by Rose's processes with Sulphuric Acid and Sodio-auric Terchloride are, with the exception of the first, perhaps, judiciously omitted, and Oudeman's method with Sodic Hyposulphite, Cupric Sulphate and Potassic Sulphocyanide substituted. Gibb's beautiful process for the determination of copper by precipitation with a Hypophosphite, and of Manganese as Pyrophosphate are given. Also his method of eliminating the corrections for moisture, temperature and pressure, by comparison of the volume of the gas with that of a certain volume of moist air in a graduated receiver hanging side by side with the first in the mercury bath, the value of which for 0° and 760 m.m.

has once for all been accurately determined. No drawing is given of the latest beautiful apparatus of Geissler for the determination of Carbonic Anhydride. The editor calls attention to an important modification of his own, that of filling the apparatus with Carb. Anhydride before the first weighing. The fact that the carbonate must dissolve freely and completely in the cold, and that it is difficult to effect the two weighings at the same temperature and pressure, greatly impairs the value of the process. It would have been well to notice the determination of Carbonic Anhydride, in case of certain native carbonates, by loss on blast-lamping. It is said that Lime is estimated occasionally in the caustic state, when present in small quantity. Is not this mode actually more certain and rapid, than its estimation either as carbonate or sulphate? Tables by Dietrich are given, which render the estimation of Carbonic Anhydride quick and easy. Prof. J. L. Smith's method of decomposition of Silicates with Calcic Carbonate and Ammonia Chloride, a most delightful, speedy and accurate method, and of which it would be difficult to speak too flatteringly, is transcribed in full. In the determination of Potassa and Soda it is not necessary to convert the alkalies into chlorides, provided that the acid with which they are combined, such as sulphuric, is soluble in alcohol, but no intimation of this important fact is given and the student would naturally conclude that the roundabout processes for converting the sulphates into chlorides are always essential. The modified method of Deville and Rivot for the separation of Ferric Oxide from Alumina and Chromic Oxide by ignitition, in alternate currents, of Hydrogen and Chlorhydric Acid is given without a drawing of the complicated apparatus requisite, and so meagrely that the admirable results obtainable by it would not be suspected.

Much that is valuable in Fresenius has been omitted without the substitution of an equivalent value of new and improved processes. During the past five years most of the leading chemists have given in their adherence to the new system, and before another edition is needed the great majority, probably, will follow their example. The new system has been adopted in our most advanced chemical schools, and nothing would have recommended the book more to the students who are now embarassed by learning the nomenclature and numbers according to the new system, and performing their laboratory calculations according to the old, than the elimination of this source of trouble. In typography and wood-cuts it is greatly inferior to the original work in German.

First Principles of Chemical Philosophy. By Prof. J. P. Cooke, Jr. Welch, Bigelow & Co.

Beginning with clear definitions of volume and weight, the simple relations which exist between them when expressed in terms of the French metrical system are pointed out. Then the advantage of the employment of the *crith* in chemical calculations. By reasoning from the phenomena of expansion on increase of temperature, it is shown that the movements of the molecules make themselves known as heat, and that the temperature of a body may be expressed by the general formula for the momentum of a moving mass, or $\frac{1}{2}$ m V^2. The argument is given for assuming as one of the fundamental doctrines of the new chemistry, that equal volumes of all gases, at the same temperature and pressure, contain the same number of molecules. The way of arriving at the numbers, most approximate to the true atomic weights, is stated, and the exact value of the control exercised by specific heats upon the calculation. Also the manner of computing from the symbol of a substance its per centage composition, and the way of arriving at the molecular weight of a body in the liquid or solid state by comparison with substances whose molecular weights are known. The chapter on equivalents illustrates, clearly, the meaning of the terms quantivalence and atomicity, and that on types the manner of representing the constitution of compounds by graphic symbols. The inorganic acids, bases, hydrates and salts are brought into harmonious relations on the new system, and a similar harmony is shown to reign among various classes of organic compounds, such as the alcohols, fats, ethers and glycols. In the chapter upon silicon some very interesting original views are presented concerning the formulæ of silicates and the method of computing them. We believe that this is the first text-book in which all the great theories of modern chemistry are systematically, clearly and logically presented. At the outset certain broad principles are laid down with reference to the nature of atoms and their relations to the chemical and physical forces, and upon these principles, as a foundation, the phenomena of chemical science are built up into a symetrical and imposing superstructure. The great strength of the book, however, is in the vast array of numerical problems by which the principles are illustrated. They test the knowledge of the student in every possible way, and greatly increase his power of applying it. The book is no ordinary one, but it is to be placed with those distinguished few like Fresenius' Analysis, Herschel's Astronomy and Dana's Geology, which mark an era in the history of instruction in the sciences to which they relate.

Elements of Chemistry. By W. J. Rolfe and J. A. Gillet; eighth edition, revised and enlarged. Woolworth, Ainsworth & Co., 1870.

Largely compiled from the former, and worthy of recommendation to less advanced students.

New Lighthouse Apparatus.—In the Lochindaal Lighthouse, in the island of Islay, Argyleshire, which was exhibited for the first time on the 15th instant, dioptric prisms of a new form have been introduced. The light which passes behind the flame has hitherto been sent forward by two optical agents, so as to mingle with the front light, and thus to reach the eye of the mariner; but the object is now effected for part of the upper core of rays by means of the new prisms alone, so that one agent is saved, and the loss of light by absorption and superficial reflection is prevented.

The prisms act by refraction and total reflection, and consist of glass of the ordinary index of refraction. By means of the prisms and a spherical mirror, the whole of the back light is sent forward.

The Working of Bronze.—The secret of the manufacture of Chinese gongs seems to have been revealed recently by M. M. Julien and Champion, who have found that bronze, which is brittle at the ordinary temperature, becomes malleable at a dull red heat. Experiments lately made on this matter at the Paris mint with the view of determining the conditions most favorable to working the alloy, found that a bronze containing 20 per cent. of tin, which at the common temperature is as brittle as glass, may, at a dull red heat, be forged and beaten out as easily as soft tin.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, February 9th, 1870.

The meeting was called to order with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the Minutes of the Board of Managers and stated that the new Board organized on the 26th January inst., by appointing the following Standing Committees for the ensuing year:—

1st. *On Instruction.*
Henry Morton,
Robert E. Rodgers,
Enoch Lewis,
Isaac Norris, Jr.,
Wm. P. Tatham.

2nd. *Elections and Resignations.*
Henry G. Morris,
Henry Cartwright,
Samuel Hart,
William Helm,
Theodore Bergner

3d. *Stocks and Finance.*
William Sellers,
Frederick Fraley,
Jacob Naylor,
Washington Jones,
William B. Bement.

4th. *On Publications.*
Bloomfield H. Moore,
Samuel Sartain,
Charles Bullock,
Pliny E. Chase,
Joseph M. Wilson.

5th. *Exhibitions.*
J. Vaughan Merrick,
William Sellers,
Edward Longstreth,
Charles S. Close.
Blomfield H. Moore.

6th. *Sectional Arrangements.*
Henry Morton,
R. Eglesfeld Griffith,
Henry W. Bartol,
John H. Cooper,
W. Barnet LeVan.

Messrs. Bloomfield H. Moore and Charles Bullock were elected Curators for the ensuing year.

At the stated meeting held February 9th, donations to the Library were reported from the Royal Astronomical Society, the Statistical Society and the Society of Arts, London; and the Association for Preventing the Explosion of Steam Boilers, Manchester, England; la Société Industrielle, Mulhouse, France; die K. K. Geographischen Gesellschaft, Wien, Austria; The Smithsonian Institution, Washington, D. C.; the Board of Water Commissioners of Jersey City, N. Jersey; the Massachusetts Charitable Mechanics Association, Boston, Massachusetts.

The various committees reported their minutes. The President appointed the following Standing Committees for the ensuing year:

Library.

H. W. Bartol.
Chas. Bullock.
Pliny E. Chase.
J. Redfield.
Percival Roberts.
Samuel Sartain.
Prof. Henry Morton.
H. G. Morris.
Wm. P. Tatham.
J. M. Wilson.

Cabinet of Arts and Manufactures.

Wm. Adamson.
John H. Cooper.
W. A. Cheney.
Clement M. Biddle.
Jacob Naylor.
Prof. Edward F. Moody.
Alfred Mellor.
Wm. G. Rhoads.
J. S. Bancroft.
Wm. P. Tatham.

Cabinet of Minerals.

Clarence S. Bement.
Dr. Isaac H. Conrad.
Dr. Elias Wildman.
Dr. S. B. Howell.
Dr. F. A. Genth.
Theo. D. Rand.
Joseph M. Wilson.
Dr. Albert C. Peale.
John C. Trautwine.
G. Brinton Phillips.

Models.

Wm. B. Bement.
Edward Brown.
Theo. Bergner.
John Gœhring.
Addison Hutton.
John Kile.
D. S. Holman.
Edwin Smith.
Joseph M. Wilson.
Chas. McIlvain.

Meteorology.

Dr. Chas. M. Cresson.
Dr. Geo. G. Percival.
Dr. Henry Hartshorne.
Dr. Isaac Norris.
Prof. James A. Kirkpatrick.
Prof. Henry Morton.
Prof. James A. Meigs.
Pliny E. Chase.
Prof. Robert E. Rogers.
A. M. Spangler.

Meetings.

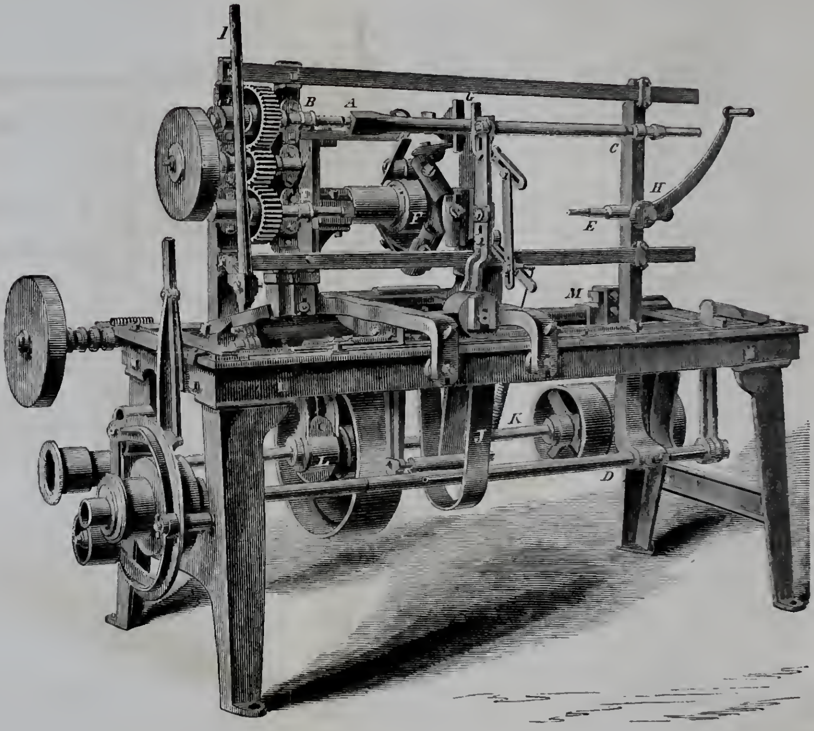
Henry Cartwright.
Enoch Lewis.
Prof. Robert E. Rogers.
Edward Longstreth.
H. G. Morris.
Dr. R. E. Griffith.
B. C. Tilghman.
Prof. Henry Morton.
Bloomfield H. Moore.
Samuel Hart.

The Resident Secretary read his report on Novelties in Science and the Mechanic Arts.

The meeting then, on motion, adjourned.

HENRY MORTON, *Secretary.*

A Fish-hook Machine.—There is a machine at New Haven, Conn., which turns out one hundred fish-hooks per minute from a coil of wire.



SPOKE TURNING LATHE.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LIX.] MAY, 1870. [No. 5.

EDITORIAL.

ITEMS AND NOVELTIES

Spoke Turning Lathe.—In the accompanying engraving, we illustrate a machine for spoke turning, designed and built by J. Gleason, Engineer. Constructed on the principle of the Blanchard patent, this lathe has been considerably improved by Mr. Gleason, so as to render it more durable and compact, while it remains as simple as before. The improvements have also given it a greater speed in the execution of the work. Built of iron, (except the few pulleys necessary to change the speed) the weight of this machine is about 1600 pounds. Mr. J. Gleason's lathe differs from those in use in the following respects:

The uprights B and C, forming part of the rocking frame, are fastened to the rock-shaft D by set-screws. Upright C is movable on shaft D, with wrought iron cross bars above to take in any desired length of model. The centre for holding the model in the upright C, and centre E for holding spoke, admit of being set in or out to any position so as to turn spokes from the same model of different lengths. Centre E is worked by the eccentric lever H, and is capable of holding the largest of spokes, which saves a great deal of time compared with the old style of driving the centre in with a mallet. Shaft D extends outside to the left of the machine, and pulleys for driving the model and feed run loosely thereon. The pulley which drives the cutting wheel F above, has a mandril running in bearings L, one on each side. The hollow mandril is fitted with two feathers which fit into slots that run the whole length of the main shaft K. The bearings L are part of the carriage, which extends down on the opposite side to receive the hollow mandril, carrying the pulley which drives the cutter wheel F. By this arrangement the carriage, cutter wheel, and pulley which drives the cutter wheel, have liberty to slide on shaft K when it is in motion or at rest.

This makes a great saving in cutter wheel belts, for in the old way the belt had to be dragged over the entire length of a clumsy wooden drum, extending nearly the whole length of the machine. Speed of driving shaft K, 600 turns, with pulley 11 inches in diameter, 4¾ inches face. These lathes are made in the very best manner. They will turn from 1000 to 1200 one inch spokes in 10 hours.

The Broadway Pneumatic Railway.—[While we cannot agree with all Mr. Haswell's conclusions in the subjoined letter, we think there is much in his argument worthy of attention.]

New York, March 29, 1870.

SIR :—In compliance with your request to present you with my views upon the operation and utility of the Broadway Pneumatic Underground Railway, in process of construction in that Street, I submit the following :

The design of the way is that of two circular and parallel tunnels, of an internal diameter of eight feet, running under and within the line of Broadway.

The method of operation is the propulsion of cars upon rails by the blast of an air or blowing engine.

The source of propulsion is an air engine at each terminus of the route, receiving its supply from one tunnel and discharging it into the other.

The transit of the cars is dependent upon the capacity of the air engine to propel them, after deducting the loss of power consequent upon the many escapes of air inherent and unavoidable in this system of propulsion, and for the purpose of illustration, I further submit the operation of a single car in its transit, at the locations of Tenth and Canal Streets.

The following elements are taken from the description of the enterprise, as published by the Company, from an officer of the Company, and from visual examination of the way itself:

Diameter of tunnel, 8 feet = 50·26 square feet.

Power of engine 100 horses.

Pressure of air, 2 ounces per square inch.

Car 100 feet in length, which, assuming it to be filled with passengers, would weigh at least 16 tons, but as a car of this length and weight would be wholly impracticable, for causes which will be hereafter shown, I assume one of but 30 feet in length, and weighing 6 tons.

The other elements are not arbitrary with the Company, but are the result of inflexible physical laws.

1. Space between a car 30 feet in length and the internal surface of the tunnel, to admit of asperities of construction and the vibration of the car upon its springs, &c., 3 inches.

2. Angle of deflection of Broadway at Tenth Street, 22 degrees. Grade of Broadway from Canal to Leonard Street, 1 foot in 56 feet.

3. Side space required in addition to the 3 inches to enable the car to pass at Tenth Street, $3\frac{3}{4}$ inches.

This space is the versed sine of an arc of a circle, of which 30 feet (the length of the car) is the chord, and 350 feet the radius.

Top space required, also in addition to the 3 inches, to enable the car to pass at Canal Street, 5 inches.

4. Traction of car and load upon the rails, including resistance to vibration, curves, &c., 8 lbs. per ton; and resistance due to elevation of 1 foot in 56, 40 lbs. per ton; making the sum of resistances, $8 + 40 \times 6 = 288$ lbs.

5. Reduction of area of end of car by the spaces required as above, 12·56 square feet or $\frac{50·26}{12·56}$ = one-fourth.

6. Area of end of car, 50·26 — 12·56 = 37·7 square feet.

Assuming, then, the pressure of the air at 2 ounces per square inch, the actual pressure upon the end of a car would be $37·7 \times 144 \times 2 \div 16 = 678·6$ lbs.; and as there is a space around the car of 12·56 square feet, or one-fourth of the area of the tunnel, the question arises, what proportion of this air would escape around the car through this non-resisting space, without imparting any impelling force to it, the car itself presenting a positive resistance of 288 pounds, or 7·64 pounds per square foot of the car?

If one-half of it escapes the pressure would be correspondingly reduced, and there would be left but 678·6 ÷ 2 = 339·3, which reduced by 288 lbs., the resistance leaves but 51·3 pounds, to propel the car; from which is to be deducted all the loss of power by the escapes of air every time a door or passage way, at any part of the route, is opened, and the unavoidable and frequent discharge of the vitiated air arising from the exhalations of the passengers, the combustion of illumination, &c., &c.

It is also to be borne in mind that the escapes of air will be in direct proportion with the number of cars run and of passengers carried; hence, any approximation to the accommodation of the number of passengers requiring facile transportation on the line of Broadway would render the transit of the cars wholly inoperative.

If our State Legislature should be disposed to entertain a favorable opinion of the means of transit, from the partial exhibition of it in Broadway and the number of signers to a petition for its introduction, it is not amiss to call their attention to the following:

The portion of the way constructed is in a right line, and does not present the obstacles referred to and consequent upon a deflection of the line. The space at the terminus of the way, communicating with the open air, cannot exist when the road is in operation. The manner of lighting the way, the non-exhibition of the operation of the car and the asking of visitors, upon presenting their tickets, and before they have seen the way, to sign a paper which proves to be a petition to the Legislature, and which a large majority of them consider merely a record of names, displays more humor than truth.

Reviewing then, the elements and deductions submitted, I am of the opinion that the Pneumatic Tunnel under consideration, is, for the purpose of passenger transit, not only impracticable of utility, but that its existence tends to retard and embarass all endeavors to give our citizens a sub-way between the extremes of the city, which is so imperatively called for.

I am, respectfully yours, &c.,

O. VANDENBURGH, ESQ. CHAS. H. HASWELL.

The New Tunnel under the Thames.—The new tunnel does not detract from the merits of Brunel's great achievement in constructing the renowned passage between Rotherhithe and Wapping, but it is as great a wonder in its way, and in several respects offers a marked contrast. The old tunnel brickwork is 38 feet wide by 22½ feet high; the new tunnel consists of an iron tube about 8 feet diameter over all. The old tunnel was worked by a shield weighing 120 tons, accommodating 36 workmen; the new tunnel has been driven by a shield weighing 2½ tons, and accommodating at most 3 workmen at a time. The old tunnel was five times filled by irruptions from the river; in the construction of the new tunnel the water encountered might at almost any time have been gathered in a stable pail. Eighteen years elapsed between the commencement and the completion of the works in one case; less than a year has sufficed for the execution of the works in the other. The descending shafts of the one were 84 feet deep and 50 feet diameter; of the other they are under 60 feet deep and 10 feet diameter. The cost of the one was over £600,000; of the other it has been under £20,000.

At the Tower-hill shaft we found the lift in which passengers are to ascend and descend fitted and at work. It is an iron chamber nearly cubical in shape, and large enough to accommodate seven or eight persons comfortably. The entrance is by a pair of sliding doors. Guide rods are attached to opposite sides of the shaft, and corresponding grooved rollers are fixed to the sides of the lift. The lift is balanced by a large cast iron weight with an open centre to admit of its being loaded in accordance with the number of passengers that have to be raised or lowered. There is a continuous connection above and below between the lift and the balance weight by chains and wire ropes, calculated for 50 times the strain that can ever be put upon them. These pass over pulleys at the top and bottom of the shafts. The balance weight works also in a pair of guide rods. Mr. Barlow has designed a brake attached to the roof of the lift, and acted on by a powerful double-handed screw on the inside of the roof. The effect of applying the brake is to release two arms which clip the guiding rods on each side, and effectually stop the descent in a few feet. At the bottom of the shafts, and under the level of the subway, are engine rooms and coke cellars. The engines at each end are of 4 horse-power, and these will at any time supply more than sufficient power for all purposes. The lifts are adjusted at each end with their doorways inwards towards the subway. On emerging at the bottom of the shafts, the passengers enter a chamber, which constitutes the "station," at and from which the one omnibus which constitutes the entire "rolling stock" in use at one time, arrives and departs. There is space in these waiting rooms for a seat along each side. We found the workmen at the Tower-hill shaft busy with the fittings and finishings of this chamber, and passing thence we entered the subway and proceeded through its entire length under excellent guidance. Ordinary passengers when the tunnel has been opened for traffic will not realise the curious sensation and experience of a passenger through on foot, from the noises overhead, on and near the river, so distinctly heard in the subway, which is air-tight as well as water-tight. Arrived at the Tooley Street end we found the waiting room occupied by the the light iron omnibus in which passengers are to be conveyed. The vehicle, seated for fourteen passengers, is tolerably roomy as regards width, but is necessarily rather low in the roof. The seats, cushioned and with stuffed backs, are placed lengthways, the entrances being at the ends. The wheels are 16 inches diameter, and at each end of the carriage a powerful lever brake is fitted, to be worked by the conductor with his foot. The service will of course be of the shuttle character, the two halves of the omnibus being duplicates, the front end of the vehicle in one journey being the hinder end in the return. The gauge of the rails is 2 feet 6 inches, and the descent from each end to the centre of the subway is by a gradient of 1 in 30. We found the works connected with the Tooley Street shaft rapidly approaching completion, but not quite so near it as those at the north end; the subway itself may be pronounced finished, and the omnibus fit to take the road at any moment.

The omnibus will be hauled by a wire rope running upon a horizontal pulley wheel fitted between the rails at one end, and passing round a vertical pulley wheel at the other.

Bridge Construction in 1869. The Kansas and Missouri Bridge.—Our attention has been drawn to the fact that in an article on the subject indicated in the first part of the above heading, on page 100 of the present volume, no mention was made of the Kansas and Missouri Bridge, of which the approaches and substructure, with the exception of one pier, are nearly complete.

This bridge was designed and located by Mr. W. W. Wright, Engineer in Chief, and is being constructed under his supervision. The superstructure is to be of wrought iron, resting upon cast iron piers, formed of large pneumatic piles sunk to a bearing on solid rock. These piles are 8½ feet outside diameter, with a thickness of 1¾ inches, and weigh about 1 ton to the square foot in height. They are manufactured in sections of ten feet in length, with inside flanges at both ends to enable them to be connected together during the process of sinking, and thus form a continuous cylinder from foundation to bridge-seat. These columns will be filled with cement masonry and concrete from the bottom to an elevation ten feet above high-water line. There will be two piers of this kind in the river, and one on the eastern shore. The western end of the bridge will rest on a stone abutment. The three spans thus formed, will be each 340 feet in length, and the bottom of the lower chord will be 50 feet above extreme high water, thus leaving ample space between the piers, and sufficient height above the surface of water for steamboats to pass at any stage of the river. The approach to the bridge at the eastern end will consist of a substantial Trestle work 1,500 feet long, connecting with an earth embankment extending 2,500 feet further.

The contract for constructing the Bridge, as above described, was awarded last January to L. B. Boomer & Co., of Chicago, for $700,000, they agreeing to take $175,000 in stock of the Company in part payment for the work.

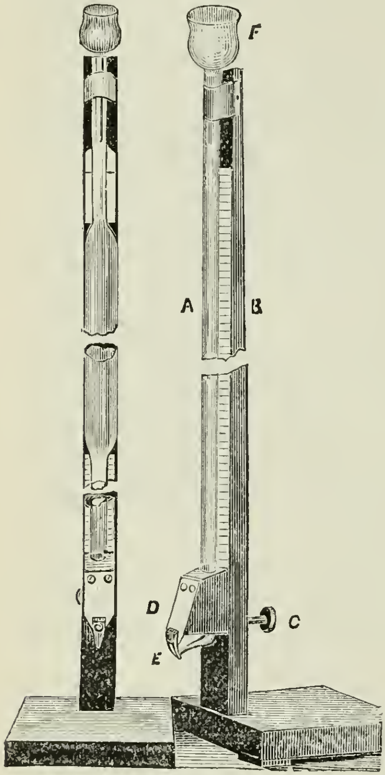
The whole cost of the bridge, including engineering and other necessary expenses, will not exceed $750,000.

Treatment of Oil for Machinery Purposes.—Oils for machinery purposes, and for lubricating generally, may be purified by agitating them with from 4 to 8 per cent. of their weight of a caustic soda lye, sp. gr. 1·2. After twenty-four hours repose, the supernatant oil is decanted from the soapy sediment, thoroughly washed with pure cold water, left to repose, again decanted and filtered, best through some animal charcoal, such as is used for the filtration of sugar syrups in sugar refineries, and through the woolen tissue, also in use in these establishments. This treatment renders the oils very suitable for the purpose intended, and is quite free from any action on the metals.—*Chemical News.*

Burette for Volumetric Analysis.—Communicated by J. Blodget Britton.—There has been in constant use, for the last four years, at the Iron Masters' Laboratory, in determining iron in metals and ores, a very convenient and serviceable Burette.

Figures 1 and 2 represent two of the kind, but of different patterns, mounted on walnut wood stands; the former is for metals and the latter, of smaller capacity, for ores.

Fig. 1. Fig. 2



Securely fastened to the upright B is a graduated tube A, having its lower part drawn out in the usual manner, but bent outwards at an angle of about 25 degrees. E is a piece of cork rivetted to a sheet-steel spring D which presses tightly, by means of the latter, against the vent of the tube. C is a thumbscrew passing through the frame and bearing against the spring.

The tube of Fig. 2 has a capacity of 100 C. C. and is graduated into tenths, or 1000 degrees; but that of Fig. 1 has a capacity of 150 C. C. and is graduated into 20ths, though only at its lower and narrow part.

Mode of operating.—Place a small, narrow-necked funnel in the tube as shown by the figures; pour in the solution to be used until it quite reaches the funnel, and then remove the latter to carry away any floating bubbles; turn the thumbscrew and bring the top line of the solution exactly to the 0 line of the scale; stop the flow, and afterwards touch the point of the cork with a glass rod to take from it any adhering drop. The instrument is then ready for use. By means of the thumbscrew the dropping may be controlled with *extreme nicety* or *instantly* stopped. Cork, after a little use, becomes quite inert towards permanganate of potash. The occasional application of some pure tallow to the end of the tube and cork will be quite effectual in preventing any of the fluid from running upwards by capillary attraction.

For every day use in the laboratory, as well as for very accurate determinations, I think this burette will find favor.

Preservation of Butcher's Meat.—By M. Gorges.—The process in use on the large scale by the author, at Montevideo, is briefly as follows:—The meat, in pieces weighing from 2 to 50 kilos., is placed in a mixture of water, (85 per cent.) the rest being hydrochloric acid, glycerine, and bisulphite of soda. After having been steeped for some time, the pieces are taken out and dusted over with finely-powdered dry bisulphite of soda, and then packed in air-tight boxes, filled as full as possible. In this state the meat keeps fresh any length of time, and becomes perfectly fit for use, equal to fresh butcher's meat, by steeping a short time in water, to which vinegar has been added, and afterwards exposure to air. The author manufactures, at the place above named, an excellent extract of meat, which can be sold in Europe at 6 francs per kilo. The price of the preserved meat, of which it would be easy to supply to London and Paris daily over 10 tons, is from 50 to 60 centimes per kilo.

Floating Matter and Beams of Light.—In a late number of *Nature*, under the above title, we find a very interesting paper by Prof. Tyndall, on certain experiments made with those concentrated beams of light with which he has been of late so much occupying himself. He observed that when the track of the beam was plainly defined in the floating matter of the air, the flame of an alcohol lamp, held below the luminous band, seemed to cast into it a column of black smoke. A hydrogen flame produced the same effect, which was no doubt due to the destruction of the floating matter, and thus the production of the non-luminous condition of planetary space, by the removal of all particles capable of reflecting light. It was then, however, noticed that a red-hot poker produced a similar effect, though less in degree, and that even a flask of hot water likewise developed a similar effect though with yet less intensity. The explanation of this effect is that the pure air being expanded by the heat much more in proportion than the solid particles, was caused to produce ascending currents of entire purity, the dust particles being left behind.

Spontaneous Generation.—In connection with the above observations, Prof. Tyndall has pointed out that this intense light may be an available means of testing the absolute freedom of vessels, air and liquids, from sporules, germs and the like, which play so important a part in the experiments which have been made on the above-named subject. Thus M. Pouchet considered that he had strongly supported the theory of spontaneous generation by finding organisms in water obtained by burning hydrogen in air, but this air was of course full of floating matter, and by means of the powerful light-beam, Prof. Tyndall showed that some water, prepared exactly in the manner described by Pouchet, was full of such floating matter.

Pasteur, the opponent of Pouchet, on the other hand, took twenty flasks filled with a decoction of yeast, boiled and hermetically sealed while boiling. Ten of these were opened in the cellars of the Paris Observatory. In only one of these did any organism afterwards manifest itself. The ten others opened in the courtyard soon showed signs of life. Tyndall placed in his light-beam a closed flask from the cellar of the Royal Institution, it appeared black and void, while another, filled with air of the lecture room was seen to be cloudy with reflecting particles. Thus in the cold, damp cellars the floating matter, germinal and other, settled down and left the air perfectly pure, while elsewhere it was full of the seeds of organism.

Philosophical and Mathematical Instruments.—We notice from a circular letter just received that Mr. James W. Queen whose apparatus has been frequently noticed in our pages, is retiring in favor of Messrs. Fox, Cheyney & Walmsley, who will carry on the same business under the title of James W. Queen & Co., at the former location 924 Chestnut Street.

The present firm propose dividing their business into three departments, each partner giving one of those departments his special care and attention.

Samuel L. Fox will devote himself to the mathematical department, which will comprise drawing instruments of every description, surveying compasses, engineers' transits and levels, surveying chains, tape measures, drawing papers and materials of all kinds used by engineers and draughtsmen.

Jesse S. Cheyney, formerly principal of Friends' Select School, in this city, will take the Department of Philosophy, which will comprise magic lanterns, oxy-calcium and oxy-hydrogen stereopticons, with pictures and illustrations from all countries and upon all scientific subjects, thermometers, barometers, globes, air pumps, electric machines, magnetic apparatus, &c., &c.

William H. Walmsley, well known throughout the country as a microscopist, and also a preparer of microscopic specimens, will take the Department of Optics, which will comprise spectacles, microscopes, microscopic objects and accessories, opera glasses, spy glasses, telescopes, opthalmascopes, &c., &c.

The Valve Jar, for preserving fruit, vegetables, &c. At the last meeting of the Franklin Institute, there was exhibited this improvement in construction and arrangement, which will be easily understood by reference to the accompanying figures. Fig. 1 represents the various parts in a separate state. We here see a glass jar with a spiral recess or thread cast around its upper portion. Into this thread screws a brass wire, which, bending over at the top, bears upon the centre of a glass or metal lid, which, by means of a rubber washer, makes an air-tight joint with the upper rim of the jar.

Fig. 1.

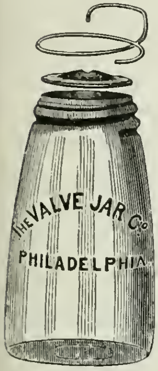
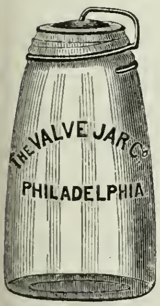


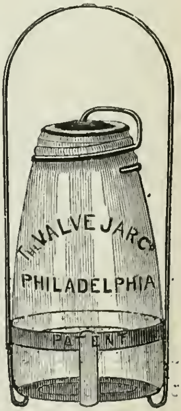
Fig. 2 shows the various parts in their proper positions.

In use, the articles to be preserved are put in the cans and the covers are screwed in place by the wires as is shown in Fig 2. The whole affair is then placed in a kettle of water and boiled for whatever time is required by the article in question. The lid of the jar being secured by the *elastic* pressure of the bent wire suffers the expanded air and vapor to escape, and when this has passed out and the jar is removed from the water and allowed to cool a perfect vacuum and secure closure is obtained by the force of the spring aided by the atmospheric pressure on the lid. Fig. 3 shows a simple sort of frame by means of which the jars may be readily placed in and removed from the water. Should the contents of a jar by any accident come to ferment the valve cover will allow the gas produced to escape, and so prevent the bursting of the jar and the destructive and annoying consequences likely to result from such an accident.

Fig. 2.



Eig. 3.



The Corona.—Among the many theories suggested to account for the Corona, I have not seen revived Meyer's hypothesis of its origin. In his essay "On the Dynamics of the Heavens," he says: "As cosmical masses stream from all sides in immense numbers towards the sun, it follows that they must become more and more crowded as they approach thereto. The conjecture at once suggests itself that the zodiacal light, the nebulous light of vast dimensions which surrounds the sun, owes its origin to such closely packed asteroids. However it may be, this much is certain, that the phenomenon is caused by matter which moves according to the same laws as the planets round the sun, and it consequently follows that the whole mass that originates the zodiacal light does not surround the sun uniformly on all sides; that is to say, it has not the form of a sphere, but that of a thin convex lens, the greater diameter of which is in the plane of the solar equator, and consequently it has to an observer on our globe a pyramidal form. Such lenticular distribution of the masses in the universe is repeated in a remarkable manner in the distribution of the planets and the fixed stars." He doubtless refers in the above passage to the coronal light, not to the Aurora Borealis, and his suggestion is certainly worthy of consideration, especially in connection with the wonderful conclusions he arrives at in the same essay as to the source of solar heat. The asteroids falling in a shower towards the sun with such tremendous velocity would by their attrition produce a sheet of light of gradually increasing intensity.* As the meteors which fall upon our earth are composed almost entirely of iron, we may suppose those reaching the sun to contain that metal as a predominant element. Although the spectroscopic observations of the corona differ, Prof. Young having detected several bright lines and Prof. Harkness only one, by both the presence of iron is rendered highly probable. J. Douglas, Jr.

Quebec, April 30th, 1870.

The Cryophorus, etc., with Bunsen's Pump.—Prof. Cooke finds that the Bunsen Pump will serve admirably for freezing the cryophorus by evaporation of ether. The lower bulb is wrapped about with several folds of cotton, which are drenched with ether, the tube being passed through an india rubber cork fitting into the tubulure of a receiver, which is placed upon an air-pump plate connecting with the Bunsen pump. The cold produced by the rapid evaporation of the ether in vacuo, causes the water in the upper belt to freeze rapidly. Bunsen's pump is applicable not only in this but in many other cases in which the condensation of moisture, or the presence of corrosive gases and liquids forbid the employment of the common air-pump. As for example, the familiar experiment of making tepid water boil violently when placed in a partially exhausted atmosphere. Indeed, Bunsen's pump may be made to take the place of the air-pump for almost all purposes, and forms a most valuable adjunct not only to the laboratory, but also to the lecture-table.

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* Page 272 of Youmans' Collection of Essays on the Correlation and Conservation of Forces.

In the filtration of large quantities of acids, alkalies, etc., a funnel may be employed of a half-gallon capacity or larger, and closed by means of sealing-wax with a conical plug of pumice of about $\frac{3}{4}$ths of an inch in thickness. The bulb of the funnel is then passed through the tubulure of a receiver as above. Besides this useful contrivance, Prof. Cooke has found the Bunsen filter to work well where large masses of precipitate must be dealt with. In this case a zinc cone, three inches in depth, which is cut, formed up-and soldered in the same way as the small platinum cone, described by Bunsen, is fitted into a large funnel. Several pounds of precipitate may be thrown upon a single thickness of filter paper, which is supported by a cone of this description, and washed rapidly and completely under atmospheric pressure. If it is not desired to preserve the filtrate and wash-water, the tube of the filter may be fitted directly into the exhaust-pipe of the pump, and the liquid carried off along with the air. Such arrangements as those detailed above would greatly economise the time, labor and working space of phamaceutists and manufacturing chemists. A. R. L.

CHEMICAL ITEMS.—Tantalum and Niobium.—By Prof. Albert R. Leeds.—In a long and interesting review of the great investigation of Tantalum and Niobium, which occupied the last twenty years of H. Rose's life, Rammelsberg recomputes the formulæ according to the modern theories of chemistry, and shows that Rose's mistakes were not so much in the analyses as in the formulæ he deduced from them.* Blomstand and Marignac have already pointed out that Rose fell into the error of regarding as a chloride, what they demonstrated to be an oxychloride.

In order to obtain metallic Tantalum Berzelius heated Tantalo-potassic Fluoride with Potassium; on treatment with water there remained behind a heavy black powder. H. Rose employed 3 parts Tantalo-sodic Fluoride and 1 part Sodium. Here also remained a heavy powder which contained a considerable quantity of Sodic Bitantalate. Marignac reduced Tantalo-potassic Fluoride with Aluminum. By treatment of the regulus with Chlorhydric Acid, a grey crystalline powder remained behind of the composition $Ta_2 Al_3$. Marignac did not succeed in preparing pure Tantalum and up to the present time it is unknown. The impure Tantalum obtained by Rose conducted electricity very well, changed with incandescence on heating in the air into Tantalic Acid, and was attacked by no acid except Fluohydric, and by that very slowly, The atomic weight of Tantalum as determined by the decomposition of Tantalo-potassic Fluoride into Tantalic Acid and Potassic Sulphate was 182. Tantalic Chloride was obtained by heating Tantalic Acid and Carbon in an atmosphere of Chlorine. It melts according to Deville at 241°·6 C. and votalizes entirely, forming a crystalline sublimate. According to the same chemist it fumes in the air, expels HCl and covers itself with Tantalic Acid. Its formula, as derived by Rose, from the amount of chlorine it yielded, is $TaCl_5$. To prepare pure Tantalic Acid it is recommended to decompose Tantalite by fusion with Potassic Bisulphate, and to fuse the salts which separate out with Acid Fluoride of Potassium. The difficultly soluble Tantalate is allowed to crystallize out of the solution of the double fluorides, and is decomposed by heating with Sulphuric Acid, etc. It is white, when heated faintly yellow, and has a formula $Ta_2 O_5$. Its numerous salts are arranged by Rammelsberg in five series corresponding to the different stages of saturation of the acid.

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* Jour. fur prakt. Chem. p. 334. 1869.

Tension of Gases Evolved from Solid Compounds.—The law made known by Deville that the tension of the gas-mixture arising from the disassociation of gaseous and fluid bodies, increases with the temperature, and at a certain temperature always has a certain magnitude, was, as is well known, extended by Debray to all solid bodies which contain a fixed and a volatile constituent. Thus Iceland Spar, by heating in a vacuum to 860° C., is so far decomposed, that the maximum tension of the Carbonic Anhydride thus set free, corresponds to 85 millimetres, by heating to 1040° to 520 m. m. It is possible, therefore, from the tension of the CO_2 set free from Calc Spar, to determine as accurately the corresponding temperature, as from the tension of saturated steam, its temperature. A Pyrometer constructed upon this principle has been proposed by A. Lamy.*

Application of Mica as a Substitute for Bronze.—A means has been found of greatly increasing the value of Mica, by converting it into a coloring material. The mica is reduced to small pieces in a stamping mill, digested with Chlorhydric Acid, cleansed by washing and sorted by sieves into sizes. The mica scales so prepared have a beautiful vitreous lustre, a silvery appearance, and bear in commerce the name of Brocade Crystal Colors or Mica Bronzes. The advantages of these brocades over the common metallic ones are:

1. They contain no unwholesome substance.
2. They possess a metallic lustre like the metallic brocades, and much surpass them in splendor.
3. Brown, blue, black, green and red colors of rare brilliancy can be obtained, which is not the case with the metallic brocades.
4. They are not dimmed by sulphur vapors.

The analyses by Dr. Cech and Schneider show that the coloring matter of the rose-brocade is cochineal; that of carmine is fuchsine; bright red, fuchsine and havanna-brown; violet, Hoffman's violet; bright blue, Berlin blue; dark blue, probably impure aniline-blue or Girard's violet; light and dark green, a mixture of aniline blue and curcuma; gold, curcuma; silver, the mica alone, etc.†

Bronzes Protected from Discoloring by means of Oil.—The fact that in all large cities, especially where coal is burnt, bronze monuments quickly present a dirty, black appearance, has incited the Society for the Promotion of Mechanic Arts in Prussia, to undertake some experiment looking toward a remedy. Analyses of ten bronzes, which were remarkable for their beautiful surface, showed that their constituents varied too greatly to permit the composition of a bronze being taken as a cause of their retaining a proper surface or not. Attention having been drawn to the fact fact that those parts of public bronzes, which were most handled retained a fine surface, it was surmised that the presence of fat might exert an influence. The surmise has been tested by exposing for some years a bronze which was daily rubbed with oil, the excess being removed by a rag, along with three others, one of which was daily cleansed with water, a second treated in the same way, but twice during the year coated with oil, and a third was left untouched. The first was very beautiful, the third less so, the second had nothing of the beautiful surface, the last was dull and black. It is hoped that the discovery may enable us to preseve the statues in large cities bright.*

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* Compt. rend. t. 69, p 347, quoted in Jour. far. prakt. chem. p. 382, 1869.

† Jour. fur. prakt. chem. p. 291, 1869.

Illustrating the Gain in Weight of Burning Bodies.—A very striking mode of demonstrating in the lecture-room that burning bodies increase in weight, has been contrived by H. Kolbe. A glass rod is fastened in a horizontal position to one arm of a balance. Upon this is fastened a glass cylinder, in which a candle is burnt, connected with which, by a glass tube, there is a V-tube for condensing the vapor, a flask filled with lime-water for Carbonic Anhydride and two more U-tubes containing Soda Lime. The last are connected by an india-rubber tube with a Bunsen's pump, by which a steady current of air is drawn through the apparatus. The beam is first counterposed; as the candle burns away the arm of the balance, to which it is attached, sinks down until its progress is arrested by the table.†

Crystalline Alloy of Zinc and Calcium.—The production of a crystalline alloy of zinc and calcium has been observed in the preparation of calcium by the process of M. Caron. in which an excess of zinc was employed. It contains about 95 p. c. of zinc and 5 p. c. calcium, corresponding to the formula $Zn_{12}Ca$. These crystals are small octohedrons with square bases. They are acted upon by water with the liberation of hydrogen.‡

Double Sulphide of Potassium and Iron.—By heating an intimate mixture of 5 parts of sulphur, 5 of potassic carbonate and 1 part of fine iron-filings, C. Preiss has succeeded in forming a double sulphide of potassium and iron, which crystallises in red needles, has a metallic lustre, and resembles in appearance Potassic Permanganate. Its formula is KS, Fe_2S_3.§ The same compound has been obtained independently by R. Schneider, who also has formed by the replacement of iron by bismuth, the analogous compound, $KS. Bi_2S_3$.‖

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* C. Magnus, Ann. d. Phys. u. Chem. 136, 480.

† Ber. der. Berl. chem. Gesellsch, p. 237, 1869.

‡ Pogg. Annal. CXXXVI., p. 434.

§ Jour. fur. prakt. Chem. b. CVII., p. 10.

‖ Pogg. Annal. b. CXXXVI., p. 461.

Civil and Mechanical Engineering.

WOOD WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress.

By J. Richards, M. E.

Introduction.

In the introduction of a treatise on wood machines no apology is needed—there is none. While nearly every other branch of the industrial arts have been the subject of treatise upon treatise—scientific and practical—wood machines have never been considered. The importance of this interest (particularly in the United States) gives it a rank that should have claimed at least some place in our voluminous text books, but not a line appears if we except a brief part of Prof. Rankine's late work on machine tools and Warsam on saws. Notwithstanding which it is safe to assert that with their high speed and endless modification, wood machines demand a higher grade of ingenuity in their construction than those for cutting and shaping metal. Accurate balancing, centrifugal force, the strength and arrangement of framing to resist vibration, and many other elements that enter into the construction of machines, show their greatest importance in wood tools. It is easy to calculate the strain and provide for the proper performance of cutting tools moving at 16 feet per minute, but when these cutting edges are moved five thousand feet in the same time a new set of conditions is involved, conditions that can not be predicated upon the ordinary laws of construction but must be founded upon experience and observation.

The want of the scientific consideration, to which wood machinery is fully entitled, must, in a great measure, account for the imperfect manner in which much of it is made. In many, if not in the majority of the shops, there is no system of drawings, no standard for bearings, bolts or shafting, the metal in the framing is disposed in the most unaccountable manner, in fact nothing approaching the standard of our machine tools, except the paint, which is laid on in "variegated profusion."

But it is not the province of this work to criticise, inasmuch as it is not assumed to be a text book. Yet it will not be amiss to "stir the matter up," and thus provoke that attention which the importance of this vast interest demands.

As it was stated in the outset that no apology was needed for the introduction of this work, it is superfluous, for the same reasons, to apologize for its not being a text book—there is nothing to form a text book from—the limited experience of one man can furnish but little material for such a work. If it is desired to prepare a treatise on the steam engine, on machine tools, or in fact on any of the common branches of mechanism, except wood machines, you have only to go to any scientific library and the whole thing is before you, rules, formulas, drawings, repeated by half score of writers; but to write of wood machines where are the data. Let this be a sufficient apology for the imperfect character of this treatise so far as relating to the forms of construction. And let the reader also remember that it is a "pioneer" undertaking, bearing the same relation to this art of making wood machines that Oliver Evans' work did to mill work nearly forty years ago.

Hoping that its mission will be useful, and for its charitable consideration by those interested, many of whom I have the honor to know, it is respectfully submitted.

In nearly all of the constructive arts we can trace their history back to a time when they were founded by the persevering efforts of a single person—some bold spirit, whose conceptions carried him beyond his age to meet and combat the skepticisms, if not the jeers and mockery, of those around him, and to find that

> "A man is thought a knave or fool,
> Or bigot plotting crime,
> Who, for the advancement of his kind,
> Is wiser than his time."

So far as to its origin centering in one man, there is no branch of our useful arts more marked than that of wood cutting machinery. The application of steam, as a motive power, came down to us through a number of inventors, each adding something left out by his predecessor, until the invention culminated in the labors of Watt. The first conceptions were crude and gave no useful results beyond stimulating others to new effort. The same history attaches to engineering tools for cutting and shaping metals, and while the original idea of the use of power in such operations could no doubt be traced to a kind of fatherhood in some one person, no art seems to have been so fully developed, or so nearly perfected at one time, and by one man, as the construction of wood cutting machines by Sir Samuel Bentham of England. And in attempting to search into its history and origin, there can, perhaps, be no more appropriate introduction than a personal notice of this remarkable man. We say remarkable, for when we consider the crude mechanical manipulation of his time, and the want of resources that existed, it would seem impossible to find anything to suggest, or a want to justify his labors.

As Bentham's inventions constitute nearly all that was known of wood cutting machines in the 18th century, their history at that period can not be much else than an account of his labors, which, we are sorry to say, comes down to us through scraps of history gathered from the records of English dock yards, where his machines were first applied to public use.

Brigadier General Samuel Bentham, Inspector General of the naval works of England, received a thorough classical and, it is presumed, scientific education at the Westminster school of London, which no doubt ranked high as an institution of learning at the time (1770). After completing his education his predilection for naval affairs led him to be bound to the master shipwright of Woolwich dock yard, where he served the regular apprenticeship of seven years, becoming familiar with all kinds of practical manipulation in wood and metal and receiving the best scientific instructions that could then be obtained. After completing the term of his apprenticeship at Woolwich he spent some eighteen months in visiting other dock yards to familiarize himself with any local peculiarities of their tools and work that had not found their way to Woolwich.

In 1779 Bentham was directed by the government to make a tour in the north of Europe, examining the progress of the shipbuilding and other arts. During this tour, while in Russia, he invented the first *planing machine for wood.* There is no doubt but that this was the original conception of a machine for smoothing the surface and giving dimensions to wood, and it is to be regretted that no description of the invention, as made at that date, has been preserved. Whether it operated by what he terms "rotative" motion in his subsequent patents, or whether it was a reciprocating machine, is, so far as the writer can learn, left to conjecture It would, however, be inferred from his first English patent of 1791, that it worked upon the latter principle, for "planing and making mouldings" by some means that bore a close analogy to the hand operations of the times, and corresponds to the one described in the patent cited. Bentham, with that regard for his country's interest that characterize Englishmen, communicated his invention to the British Ambassador at St. Petersburg, who advised him to keep his invention for England, which seems to have been done, as there is no account of his having made any public use of it while in Russia, where he accepted a military commission with rank of Lieut. Colonel, and became the manager or commandant of extensive factories for the production of glass, metals, cordage, works in wood, &c., his extraordinary and successful management of these works would lead us to suppose that he invented many new and useful machines; but of these there seems (in England) to be no account. He returned to England in 1791 about which time his brother, Jeremy Bentham, had received from the government an appointment to introduce *industrial prisons*, this kind of labor being almost devoid of skill. The talents of his brother was called into use to devise machines that would make the labor more profitable, and at the same time replace, to some extent, the lack of skill in the convicts. To construct these machines, most of which were for working wood, the residence of Jeremy Bentham at Queen's Square Place, Westminster, (now in London) was, with its capacious outhouses, converted into the first *manufactory of wood-cutting machines.* Seventy-eight years ago this factory was established, and, as we are informed, was not sufficiently large, and thus a building No. 19 York Street was also occupied, which would lead us to suppose that many machines were produced and that the extent of the business fully entitles it to the distinction of being called the first general factory of such machines. Prof. Willis in a lecture before the Society of Arts in 1852, states that "there was constructed machines for all general operations in wood work; including planing, moulding, rebating, grooving, mortising and sawing, both in coarse and fine work, in curved, winding and transverse directions, shaping wood in complicated forms, and that farther, as an example, that all the parts of a highly finished window sash were prepared, also all the parts of an ornamental carriage wheel were made, so that nothing remained to be done by hand but to put the component parts together." These machines were examined by members of his majesty's administration, and received public notice in the House of Commons in 1794. Bentham (Sir Samuel) was next commissioned to visit the different dock-yards and determine how far his machines could be applied to facilitate ship building. He refused a flattering offer from the Emperor of Russia to accept this commission, choosing rather to give his country the benefit of his services than to reap the greater pecuniary reward that awaited him in Russia.

His report was, no doubt, very favorable as to the employment of machines, but it was not until 1797 that the admiralty consented to their introduction. It should have been mentioned that during the time of his manufacture of machines at Westminster, and York Street, patents were taken out describing all the different operations performed, which will be more fully noticed when we come to classification of machines. After the admiralty deciding to adopt his machines in 1787, they were manufactured by Jeremy Bentham, and forwarded, from time to time, to Portsmouth and Plymouth, and performed, so far as any record shows, all that was claimed for them.

The bills specify lathes, saws, machines for cutting tenons, for boring, also for boring bitts and squaring tools "and many other machines for different kinds of work." Machines were also devised by Bentham to facilitate block making, an operation that is yet classed among the most difficult, his machines, however, for this purpose did not seem to be perfect, for in 1810 he was joined by Brunnel who had invented a machine for shaping *block shells.* Brunnel was at that time employed under Bentherm to assist in the various operations and to perfect his own machine, which must have had the endorsement of Bentham. In 1803 Sir Samuel, as Inspector General, advised the admiralty to adopt many of his machines that had already been approved, and to permit the erection of steam engines to drive them which were accordingly ordered. The several dock yards were fitted with engines for sawing, planing, boring, tennoning, mortising, &c., and aside from better construction and the greater experience in their use, it is fair to infer, had about all the functions now found in them. Their labor saving capacity is sufficiently attested by the fact that Brunnel, who had perfected and assisted in their construction and operation, was rewarded by being allowed as a premium for his inventions, the *savings* of one *year's work over hand labor* in the dock yards, which amounted, as we are informed, to the sum of $80,000.

In 1813 arbitrators were appointed on the part of the government to settle with Jeremy Bentham, who, after the examination of numerous witnesses, allowed him the sum of $100,000 for machines furnished to the dock yards and penitentiaries. From the testimony given before the arbitrators we learn that Sir Samuel Bentham "prepared a system of machinery for the employment of men without skill, and particularly with a view to convicts, in 1793—patents were taken out on these inventions to secure their exclusive use for the prisons. The testimony states that no skill was required in the use of these machines, they were introduced into the dock yards and worked by common laborers. The use of the machines saved nine-tenths of the labor—"a table could be made at one-half the expense by their use, &c., &c." which goes to show that the machines were effective, at least—a claim that can not always be made for those of more modern manufacture.

We will here take leave of General Bentham, having advanced enough to show that he is entitled to be called the *father* of wood cutting machines in England, at a date that precludes any possibility of his inventions having been anticipated in other countries. Let us in looking back over this history, surrounded as we are by the perfected art, not forget the circumstances under which these machines were made—imagine "cat-gut" bands and grooved pulleys for transmitting motion, the want of skill in the workmen to carry out designs, the want of all tools to shape metals, except the hand lathe, the imperfect knowledge of geometrical drawing, in short all of the modern appliances with which we are familiar.

A list of the inventions of Sir Samuel Bentham in wood cutting machines.

Machine for planing and forming mouldings. Improved planing and moulding machine (rotary.) Wedging guard for circular saws. Segmental circular saw. Conical cutters for dovetail grooves. Undulating carriage to form wave mouldings. Compound cutter heads to work two or more sides at once. The slide rest. Tubular boring implements (core boring.) Crown saws (or cylinder saws.) Reciprocating mortise machine. Rotary mortising machine. Radius arm for sawing segments. Tracer guide for sawing irregular forms. Bevil and curvalineal sawing. Machine for grinding saw blades. Taper gauge for sawing. Grooving Table. Vertical adjustment of saws in benches. T rabbit machine. Sectional cutters. Pivoted table for mortise machines. Forked or double mortise chisel. Gauge lathe with slide rest. Rotary cutters for forming screw threads. Double grooving saws. Rack feed for planing machines.

These several inventions were made and practically applied previous to and during the year 1793. See patent No. 1951.

We must not, however, regard the construction of the machines so remarkable as the wonderful genius displayed in the invention of the processes.

In the proceedings of a trial between the crown and Junius Smith in 1848, for the repeal of a patent on sawing machinery, reported in the *Mechanic's Magazine*, there is appended a note that pays a tribute to the genius of Bentham greater than all the honors conferred by the government during his life, from which we will quote as follows:

"Sir Samuel Bentham was the first to introduce saw mills into our national arsenals, the first also to lay down the principles of how all kinds of machine saws may be constructed, *and which have never since been materially departed from.* The specification of his patent of 1793 is a perfect treatise on the subject, *indeed the only one worth quoting that has to this day been written on the subject.*"

From about 1815 to the great exhibition of 1852 no marked inventions were made in wood machines in England, at least for general uses, many machines for special purposes were made that not only give evidence of ingenuity in their application but show high engineering talent in their construction. In 1849 Wm. Furness of Liverpool, imported from the United States, and patented in England, nearly all the leading wood working machines manufactured by C. B. Rogers & Co. of Norwich, Conn., but from prejudice, or from want of being properly brought before the public, no modification of their plans was made by English builders until after the great exposition of 1852, when they were astonished to find the small wood forming machines from America to embody much that was new, and give a performance that was, in all respects, superior to their own. This gave the art of making wood cutting machines a new birth in England. For 40 years the plans of Bentham, Brunnel and Burr had been followed, as before said, without material change, and while Joseph Whitworth and others had revolutionized the manufacture of engineering and metal working machines and implements, the wood machines had lain dormant. "Iron was king," and aside from ship building wood was not enough used in their manufactures to direct attention to machines for working it.

To follow the history of wood cutting machines consecutively, and trace their development, their history in the United States should, perhaps, date from the Woodworth patent of 1828, on planing machines. This notorious monopoly lasted, by regular extension and act of Congress, over a period of 28 years, costing thousands of dollars in some *sixty-four* suits at law which followed, and crippling the interests of our country to the extent of millions of dollars—to say nothing of the many inventions in rotary cutting machines that would have been developed had this monopoly been removed. We say monopoly, for the patent of Woodworth was never accepted as a bona fide invention with the scope that the interpretations of our courts gave it. There need be no further evidence of this given than the numerous appeals to the courts in the face of former decisions. It is true that many of these suits were in equity and did not involve the question of validity, but they nevertheless, in nearly every instance, showed that public opinion did not acquiesce in the decisions on this point. In explanation and support of the opinion expressed it must be admitted that the combination of rotary cutting cylinders and feeding rolls, would in the natural development of this art, have soon followed as a matter of course, and that as soon as lumber dressing by power was an industrial necessity, this combination would have been invented, not by a single man only, but by a majority of as many as would attempt to build planing machines, in other words the planer was a sequence of the state of the art, and the art was not dependent on the invention of Woodworth.

Cutting cylinders for reducing wood were under several modifications, known and used as we have shown in a former place, 35 years before. In 1811 a patent was granted to Charles Hammond of the city of London, for improvements in machinery for sawing and planing wood, in which he very fully describes the use of feeding rolls for passing lumber to circular and other saws. Similar feeding rolls were used for analagous purposes, and *when it became necessary* to move a board continuously under a rotary cutting cylinder, the public would not have had long to wait for the mechanical devices forming the subject of Woodworth's specification

It is not the intention of the writer to disparage the invention of Woodworth, and he begs to present these views of this old patent as coming from a practical mechanic; himself a patentee of improvements in wood machines, and as the frank expression of an opinion based upon impartial consideration of the facts.

Since 1850 the inventions in wood machines have followed each other in rapid succession in our country, the most complicated forms, regular or irregular in their cutting, are produced with an accuracy that no hand manipulation could attain, and foreign inventors in England, France and Germany have been keeping pace with us, not in producing the same machines but in adapting them to the special requirements of their respective countries. It is hereafter thought best, in the course of this work, to consider the different classes of wood working machines under separate heads, such as machines for dressing plane surfaces, machines for straight line moldings, circular, endless and reciprocating saws, duplicating machines for irregular forms, turning machinery for parallel, taper, and ornamental forms, machines for casks, barrels and pails, &c., &c., giving to each class such a share of attention as their respective importance or their intricacy demands, and the information at hand will allow.

(To be contined.)

CLEVELAND WATER WORKS LAKE TUNNEL.

The success of the Chicago Lake Tunnel has stimulated the people of Cleveland, Ohio, to a like enterprise, by which the waters of Lake Erie are to be brought to their wash basins and hydrants.

Through the kindness of Mr. F. Graff, our Chief Engineer in this department, and of Mr. John Whitlaw, C. E. of the Cleveland Water Works, we learn that a contract, in accordance with the subjoined specifications, has been let to Mr. A. A. McDonell of Chicago, for the sum of $112,600. This includes the lake shaft but not the land shaft, which is done by day work under the immediate control of the water department. The entire work is expected to cost $200,000.

As yet the progress made is the land-shaft, chamber and adit complete, and about 200 feet of the tunnel.

EXTRACT FROM SPECIFICATIONS.

Land Shaft.

To be seventy-eight feet deep, including a sump three feet below the bottom of the invert of the tunnel, and to be eight feet clear diameter from five feet below the surface of the ground, the upper five feet to be lined with brick masonry twelve inches thick and to be nine feet clear diameter, the following thirty feet to be lined with cast iron cylinders, four in number, nine feet outside diameter, and one and a half inches thick, with flanges upon the inside two inches thick and six inches wide, the lower cylinder to have but one flange, all of the flanges to be faced in a lathe, true and at right angles to the centre line of the cylinders, the joints between the cylinders to be made with red lead mixed thin with boiled linseed oil, and bolted together with forty-two one and a quarter inch bolts with hexagonal heads and nuts, in such a manner as to form water-tight joints, the iron to be of good quality and free from sand holes or other defects, and the castings to be smooth and true on both sides.

From the bottom of the castings down, a distance of forty-three feet, the shaft is to be lined with brick masonry, the wall to be twelve inches thick; the bottom of the shaft to be lined with brick work twelve inches thick in the centre and two feet thick under the wall, laid in the form of an invert.

Neatly formed arches, as shown on Plan 2, are to be turned in the wall at the level of the tunnel, from which to commence the tunnel under the Lake, and an adit fourteen feet in length, six feet high and five feet wide, lined with brick work twelve inches thick and terminating in a circular chamber eight feet clear diameter and eleven feet high in the centre, to be lined with brick work twelve inches thick, the bottom to be formed the same as the bottom of the shaft, the top to be arched.

All of the brick used in this work to be whole, well formed, hard burned, free from lime and clear ringing, and are to be laid with close joints on the face of the work in the inverts and arches, and the joints in the wall are not to exceed one-fourth of an inch in thickness.

All joints must be filled flush with cement mortar as each course is laid, the mortar be composed of one measure of clean sharp lake sand to one measure of fresh ground hydraulic cement, of such quality as shall be approved by the Engineer, thoroughly mixed in water, and to be used as fast as made.

The castings and brick work in the shaft to be perpendicular, and brick work to be true and neatly laid in horizontal courses and so as to break joints at least three inches. All spaces between the outside of the wall and the face of the excavation to be filled in with brick laid in cement mortar, the same as in the wall; the whole of the work to be completed as shown on Plan No. 2.

Protection Crib for Inlet Shaft.

The bottom of the crib, which is to be five-sided, is to be formed by an outer, middle and inner line of twelve-inch square white pine timber, connected by cross-timbers and braces of the same size. Each outer side is to be fifty-four feet long. Upon these timbers a floor eight inches thick is to be placed, covering all the space between the outer and inner walls, the ends of the floor timbers to be dove-tailed into the outer and inner lines of timber and into one side of the angle braces, one-half of the dove-tail being framed into the lower course of timbers and one-half into the next course above, the dove-tails to be seven inches long and the full thickness of the timber at the ends, with shoulders top and bottom, one inch deep; where the floor timbers cross the middle wall timbers or cross timbers, they are to be notched one inch deep on both upper and lower sides, and the timbers crossed by the floor timbers in the bottom course, and the next course above are to be cut away three inches to receive the floor timbers. Upon the three lines of timbers, solid perpendicular walls of twelve-inch square white pine timber are to be built to a heighth of forty-four feet, and are to be locked together with cross-timbers and braces, as shown on Plan No. 3.

The inner face of the inner wall is to be twenty-four feet from the outside of the crib, leaving an open space in the centre as shown on Plans Nos. 3 and 4.

The middle wall to be equidistant from the outer and inner walls, and is to extend through the outer wall, the timbers of the inner wall are to extend from the angles along the line of the wall and across the space between the inner and middle walls, and are to be framed into the middle wall with dove-tail joints; in alternate courses the direction of the timbers from the angles to the middle wall to be reversed as shown on Plan No. 3.

Angle braces are to extend from the outer to the inner wall four feet four and one-half inches from and parallel to a line drawn from the outer to the adjacent inner angles; five of these braces to be used in each course, and to be placed on opposite sides of the angles, in alternate courses; five cross-timbers in each course are to extend from the outer to the middle wall, in such manner that in two or more courses the space between the ends of the middle wall timbers at the outer wall will be divided into three nearly equal parts, as shown on Plan No. 3.

All of the timbers in the outer and inner walls at the angles, and all timbers connecting with the outer and inner walls, and the timbers of the inner walls and cross-timbers where they join the middle wall, are to be connected by dove-tail joints one inch deeper at the end than at the shoulder, of the full width of the timber, and of the same depth in each.

Wherever timbers cross each other they are to be halved together. All butt-joints must be made under the middle of some cross-timber, excepting in every fourth course, when bond timbers are to be used.

There are to be three inlets through the crib, each four feet wide and five feet high, the bottom and sides of which are to be formed of twelve-inch square white pine timber, and the top is to be covered with six by twelve-inch timber, closely fitted and securely bolted to the side timbers with three-fourth inch square drift bolts twelve inches long.

On the top of the three inlets, and against the outer side of the middle wall, well holes, four feet square, formed of six by twelve-inch timber, are to be built to the top of the crib, the ends of the timbers next the wall to be framed into the wall with dove-tail joints, and the courses are to be bolted together with three-fourth inch square drift bolts ten inches long; upon the sides of the wells against the walls, four by ten-inch guides of white oak, for screens, are to be run from the bottom to the top of the wells, and are to be securely spiked to the wall. See Plan No. 4.

The bottom of the lower inlet through the crib to be eight feet above the bottom of the crib, the upper one to be ten feet below the water line, as shown on Plan 4, and the middle one to be midway between the upper and lower ones.

The whole face of the inner wall, and all the face of the outer wall, to be covered with two-inch sound white oak plank, the upper fourteen feet of the face of the outer wall to be covered with a second layer of two-inch white oak plank of best quality, to be fastened to the crib with six-inch wrought ship spikes 5-16 inch square, as shown on Plans Nos. 3 and 4.

Iron Work for Crib.

The three lower courses of timber are to be bolted together with 1½-inch round wrought iron bolts, with wrought iron plates under heads and nuts, $\frac{1}{2}$ inch thick and six inches square; there are to be nine of these bolts in each of the sides of the outer wall, seven in the middle and four in the inner wall, and six in each angle brace, 4 feet long each, making one hundred and thirty in all; the bolts in the walls to be thirty-six inches between heads and nuts, as shown on Plans Nos. 5, 6 and 7.

The outer courses of timber are to be secured to each other in the outer and middle walls by $1\frac{1}{4}$-inch square wrought iron drift bolts thirty inches long, and in the inner wall by one inch square bolts of the same length. All of the bolts to be driven at an angle of ten degrees from a perpendicular, and are to incline in opposite directions in alternate rows. Forty-five $1\frac{1}{4}$-inch, and fifteen one inch drift bolts to be used in each course of timber. See Plan No. 3.

The outer angles of the crib are to be covered with $\frac{1}{2}$ inch wrought iron plates, four feet wide, and extending down from the top of the crib to a depth of twelve feet, the plates are to be bent to the exact angle of the crib, and are to lap two feet on each side; they are to be fastened to the crib by one inch round wrought iron bolts, one through each timber, on each side of the angles, the heads to be countersunk into the plates and secured with nuts and washers on the inside, with a wrought iron bar $\frac{1}{2}$ inch by six inches, running under all the nuts.

There may be five openings provided with gates in the outer wall, and two in the inner, near the bottom of the crib, for the purpose of admitting water for regulating the sinking of the crib, each opening to be twelve inches square.

In the construction of the crib, the best timber shall be selected, and used in building the upper fourteen courses.

The crib, after being towed to its proper location, shall at once be anchored in its place in a secure manner, and be filled as soon thereafter as possible with sound, clean rubble stone from bottom to top. After the crib shall have been completely filled with stone the whole surface between the outer and inner walls shall be floored over with sound white oak plank three inches thick, securely spiked to the wall timbers, cross-timbers and angle-braces, with nine-inch wrought ship spike $\frac{1}{2}$ inch square.

The angles of the crib shall be placed in such exact position as the Engineer of Water Works shall direct, and the walls shall stand perpendicular. Before sinking the crib, its site shall be thoroughly dragged and levelled, so that no boulders or other irregularities of bottom shall prevent the crib from settling upon a horizontal and even bearing.

The Inlet Shaft.

To be of cast iron, nine feet outside diameter, two inches thick, made in six sections, each seven feet ten inches long, the flanges to be $2\frac{1}{4}$ inches thick and seven inches wide on the face, and are to be faced in a lathe, true and at right angles to the centre line of the cylinders, the lower cylinder to have but one flange, and the bottom end to be turned sharp. Each flange to have a groove turned in its face, as shown on the Plan.

The cylinders to be fastened to each other by forty-two bolts to each joint $1\frac{3}{8}$ inches in diameter, with hexagonal heads and nuts, the joints to be made with thin red lead putty. The top of the cast iron cylinder to be nine and a-half feet below the water line, as shown on Plan No. 4.

From the top of the cast iron cylinders to five and a half feet above the water line, the cylinder to be of boiler iron $\frac{3}{8}$ inch thick and nine feet outside diameter, riveted to a cast iron flange and bolted to the top of the cast iron cylinder, in the manner shown on said Plan No. 4.

All the perpendicular joints to be butt joints, and to be fastened together with plates on the outside $\frac{3}{8}$ inch thick and seven inches wide, and all lap joints and butt joints to be double riveted with $\frac{5}{8}$ inch rivets, and all to be calked in such a manner as to render the cylinder perfectly water-tight. The top of the cylinder to have a cast angle iron flange, two inches thick, six inches wide and six inches deep, fastened on with two rows of $\frac{3}{4}$ inch rivets, and the sides are to be braced with two rings of angle iron riveted to the sides of the cylinder, of the form and dimensions shown on the Plan.

After the completion of the whole work, and before the water is let into the tunnel, a grate or screen, in accordance with plans to be furnished hereafter, and to be paid for as extra, is to be fastened to the top of the cast iron shaft, and the wrought iron cylinder is then to be removed and placed on the crib. From the bottom of the castings to the bottom of the shaft, a distance of fourteen feet, including a sump five feet deep, the sides are to be lined with brick masonry twelve inches thick and seven feet ten inches clear diameter, and the bottom casting is to be lined with brick masonry to the flange. Inverts and arches of the form and dimension shown on Plan No. 4, are to be built in the wall on the line of the tunnel.

The Tunnel.

To be five feet two inches high and five feet wide, clear dimensions, the top and bottom arches to be semi-circles, and is to extend from the bottom of the shore shaft a distance of sixty-seven feet eight inches below the water line shown on the Plans, out under Lake Erie, at right angles to the shore line to the lake shaft, a distance of six thousand six hundred feet, and beyond the lake shaft a distance of fifty feet, with a chamber eight feet in diameter and eleven feet high, clear dimensions, lined with brick masonry twelve inches thick, and to be located six feet beyond the lake shaft, the bottom of the tunnel to connect with the lake shaft at a depth of sixty-five feet and six inches below the water line, as shown on Plan No. 4. The grade line of the bottom to be uniform between the two shafts, or from a point between the shafts to each shaft, as the Engineer may hereafter determine. The whole tunnel to be lined with brick masonry, eight inches thick, laid in hydraulic cement, the brick to be laid lengthwise of the tunnel, and so as to break joints at least three inches. The centres upon which the upper arch is turned shall not exceed two feet in length.

The brick, mortar and workmanship, in the lake shaft and tunnel, are to be of the same character and quality as described for the land shaft.

The excavation to conform exactly to the outside of the brick lining of the tunnel, and all spaces between the outside of the brick work and the face of the excavation shall be filled in with masonry of the same quality as the lining for the tunnel. If, in the prosecution of the work any soil is met with that requires to be supported while the brick work is being laid, the space between the wall of the tunnel and the plank or timber used, shall be filled with solid masonry, similar to that used in filling other spaces, as described above.

The contractor shall furnish and put in place all timber, plank, or other material necessary for the support of the top or sides of the excavation until the brick work is laid; he shall also furnish and put in place all air pipes and apparatus necessary for the complete and proper ventilation of the tunnel, all steam engines, pumps, elevators or hoisting apparatus, and all fixtures for the same, all sheds and shelters for the protection of the workmen and materials at both shafts, and all tracks, trucks and other necessary implements or machinery for removing excavated material out of, and building material into the tunnel.

And the contractor shall be held responsible and liable for any damage that may be sustained by any person employed in, or visiting the tunnel, in consequence of the failure on his part to keep all such fixtures, implements or machinery in a safe condition for the purpose for which they are used.

The contractor shall remove all excavated material taken out of the tunnel and shafts, to such place not exceeding five hundred feet from each shaft, as the Engineer may direct, and shall provide for such purpose all the necessary implements and means of transportation.

The rest of the specifications refer simply to business and financial details.

CYLINDRICAL TYPE PRINTING MACHINES.

By Hector Orr.

Read before the Franklin Institute at their Stated Meeting, March 16, 1870.

I shall assume that the *Franklin Institute* is interested in the diffusion of useful knowledge, and that Type Printing is the main instrument of such diffusion. If these assumptions are disputed I will ask that some future time be set for the arguments thereupon—and will proceed now to offer a few thoughts on the process and progress of Type Printing.

Less than fifty years ago 500 impressions per hour was the utmost amount that could be produced by two proficient workmen on the best press then known in America—the sheet of paper measuring 18 inches by 23 inches. We now have machines which print 25,000 impressions per hour, the sheet being four times the size of the former one; our present speed thus rating with that first named as 200 to 1. It required 350 years to attain 500 impressions per hour, and then, in our own generation, the speed increased 200 fold.

Whence, then, this enormous acceleration? The answer is not a long one, though capable of great elaboration:—it has been attained by the substitution of curved surfaces for flat ones in the chief points of contact. In our particular department of art it has no rival in importance, and few equals in the whole range of mechanics. It gave us an economy of power, time and space, each one of which results might give its author enduring fame, and which, united, make a desert truly illustrious.

That others may judge if this commendation is too emphatic, I will ask leave to describe, in few words, the process to which it applies.

If we take a common pin and score a soft metal or even a waxen surface by it, we may take from such lines a number of impressions of quite delicate outline by very simple means—the dead surface surrounding the inscription meeting the impressive force and bearing it off. But in type printing we must imagine the pin's point to be turned up, and the color and impression to be applied *there.* This evidently demands a careful operation, to complete which the types were placed upon a flat surface laboriously smoothed, and a similarly prepared impressing surface was forced perpendicularly down upon the letters—both being carefully guarded from vibration. Now, to change these surfaces to curves, and to expect to bring a clear impression therefrom, required a large share of mechanical courage.

Yet it was found; and I am glad to be able to name the great genius who accomplished the feat. *Mr. W. Nicholson*, editor of the *London Philos. Journal*, was the man. In the year 1790 he obtained letters patent for an improved printing press; and his formal specifications of his means and results cover nearly every important point of all his successors. His description is one of the most surprising first attempts at invention that I ever read. James Watt had but well finished the steam engine when Nicholson (another Scotchman, I suspect) conceived the Cylinder Press; and these two have given our planet a new history.

I have said that Nicholson had a well-defined idea of type printing by curved surfaces, but he had no adequate, nor even sympathising mechanical assistants. He insisted on placing the types upon a cylinder and of bringing other cylinders against the first to apply the ink and give the impression; but no type founder of his generation could meet his requirements, and the entire printing trade was bitterly opposed to his invention. As editor of the *Philosophical Journal*, we may suppose that he had both patience and perseverance, and truly he needed both, and time and money besides. But all these were insufficient to produce a complete machine: he died uncrowned by success—mortal yet invincible!

Some 24 years after the date of Nicholson's patent, a Saxon German, named Koenig, produced a printing machine in London embracing a portion of the cylindrical principle. He kept the form of types flat, and gave the impression by the circle—(a wise man, who took, thankfully, *one-half* of the former enthusiast's loaf.) The *Times Newspaper* was printed on such a machine in November, 1814, and its inventor continued to build and improve printing presses for the remainder of his life—retiring to Germany and there becoming quite celebrated.

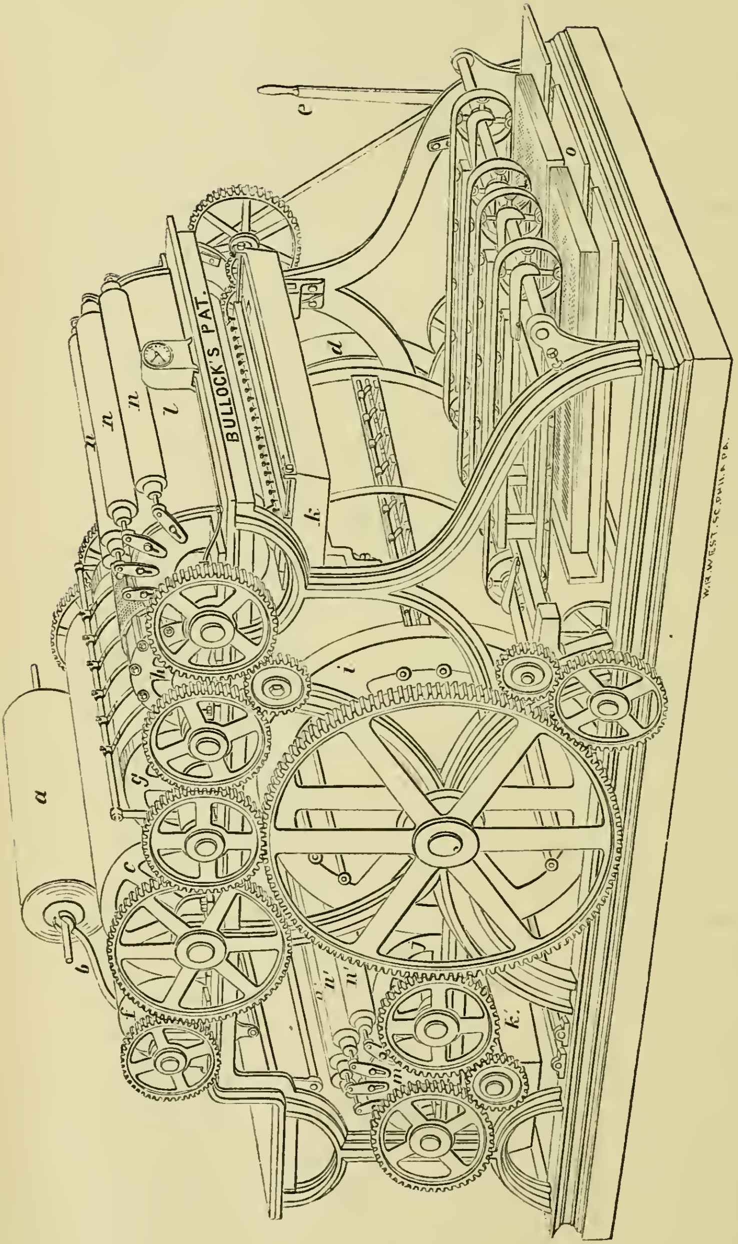
In 1816 Edward Cowper patented a Cylinder Printing Press, which still farther realized Nicholson's idea. Stereotype plates had by this time appeared, and Cowper had these *bent* and fastened to one of his curved surfaces. Cowper also applied, successfully, the celebrated glue and molasses roller—though he was not the inventor of it.

In 1825 David Napier (who had previously built other cylindrical presses) completed a double cylinder and bed press for book work, which is highly praised by Mr. Hansard in his *Typographia.*

In all this time American printers had kept rigorously to flat surfaces. The Columbian Hand Press (superior to any other of this class in the world, for years) was invented in Philadelphia in 1817. In 1826 Mr. Treadwell of Boston, brought out a platen press running 500 impressions per hour, which was introduced in Philadelphia the following year. In a short interval of time Isaac Adams of Boston, produced his style of platen press, which ran about 750 impressions per hour. With this press the celebrated "fly" was introduced—a contrivance for delivering the printed sheet from the machine; this was Adam's chief contribution to the trade, and has been adopted on most of the succeeding presses, whether platen or cylindrical.

It was not until 1830 that cylinder presses appeared in America, introduced by Messrs. Hoe & Co., of New York, and applied at first to newspaper printing; but in 1832 a registering book press was made by them, running 3000 impressions per hour. In 1839 David Morrison of London, patented the "Rotary Press" attaching movable types to a revolving cylinder, and thus, at length, attaining Nicholson's idea.

In 1847 Messrs. Hoe & Co. of New York, patented their "Rotary Type Printing Machine," which by various improvements and ex-



W. H. WEST. SC. PHILA. PA.

CYLINDER PRINTING MACHINE.

tensions has well nigh rolled over the world. This machine is composed of a great central cylinder on which movable types are securely held by ingenious contrivances, and made to pass under a series of inking rollers and impression cylinders arranged around the circumference, where numerous skilled assistants "feed" in the sheets. The largest of these machines now made have ten feeders each and execute 25000 impressions per hour. They are in use in nearly all the large newspaper offices in America, and in London, Paris, and various other important centres of civilization on the globe.

And now we come to the latest development of these machines, perfected and built in our own city--known as *Bullock's Self Feeding and Perfecting Press*—an engraving of which is here given. The paper, in a continuous roll, *a*, (see Plate) resting in simple socket bearings, has its outer edge taken between cylinders *c* and *f* and is there cut into uniform sheets, each of which is seized by fingers on cylinder *g* and brought against the first type cylinder *h;* it then passes to large cylinder *i* where its face is reversed and drawn against the second type cylinder *j*, and then carried down and onward to the "fly-belts" which pile the completed sheets on fly board *o;* the pans *k k* are the two ink fountains; *l* the first distributing cylinder, *m* the second one, and *n n n n* the distributing rollers. The press is started by the lever *e* and no other manual aid is needed except to lift away the pile of printed sheets.

This machine occupies 11 feet by 6 feet and is also 6 feet in height. It will execute 20,000 impressions per hour without the touch of human hand, except to start it. Feeding itself with paper, printing both sides of the sheets, and piling the same in a neat heap at the rate above named.

Hoe's last mammoth press claims to print 25,000 sheets per hour, with the attendance of *ten* trained men; but prints its sheets on *one* side only and costs $52,000.

Bullock's press prints 20,000 impressions per hour, entirely automatically; and is sold for $20,000.

To all this triumphant achievement there is one sad fact which I will venture to append. The inventor of this wonderful machine, Mr. William Bullock, was killed by his latest complete machine. As a practical mechanic, as well as inventor, he put his own hand to every part of the work, and in his anxious zeal he was caught in the machinery, and was extricated only to die. A mechanic's Institute will know how to estimate such a sacrifice.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 234.)

Means of Increasing Adhesion of Belts.

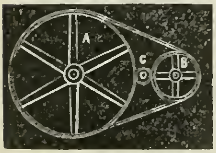
Various means have been devised for augmenting the adhesion of belts to the pulleys which they drive, to some of which we now refer. With the ordinary single and double belts where the usual tightening of the same as well as where the application of the several oily and adhesive matters in common use have proven insufficient, a very simple remedy has been applied with success, in the shape of a narrower belt drawn tightly, with ends laced in the usual way and allowed to run with, and on the outside of the same.

This is a remedy almost too simple to refer to, yet it has, in many instances, proven a valuable addition to the driving power of certain belts in a system which fails to transmit the power desired from lack of adhesion. In many cases belts do not possess sufficient tensional strength to impart the power due to their surface velocity; with such, the auxiliary belt, above referred to, is the cheapest and readiest cure.

Double leather belts are frequently employed in place of single ones to increase adhesion on the pulley surface, but while we are assured of greater tensional strength in the double belt we have no data to prove its superior adhesive power.

We have, however, the valuable testimony of Mr. F. W. Bacon, of New York, whose large experience in this line of practical engineering gives weight to his conclusions. He says:—"I never use double belts under any circumstances, I am satisfied, that other things being equal, they will not do as much work as a single belt, because they do not come in contact with as much surface as the more pliable single belts do, hence there is no advantage in doubling the thickness. If greater tensional strength is required use wider belts."

Fig. 1.



In Fig. 1 we present the invention of Mr. Alonzo Hitchcock of New York, which consists of three pulleys, each on an axis of its own, and a driving belt so placed that the driving pulley A touches the driven pulley C. These two are forced into close contact by the auxiliary pulley B, over which the belt is tightly drawn from the pulley A. The larger pulleys may be leather covered, and all should be straight on the face and have their centres in the same straight line and of course their axes in the same plane.

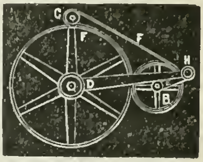
It is evident, on inspection, that the belt and pulley surfaces all favor rotary motion in the pulley C, and while the pulleys A and C may vary greatly in diameter, producing rapid increase of speed, the belt passes freely and with full driving effect over comparatively large pulleys. The pulley B being made of any diameter desired.

This combination was patented January 30, 1867. The inventor says:—"I claim distributing the power around the shaft to be driven so that the tendency to displace the shaft on one side is counteracted by that on the other by the means and in the manner shown."

A more complicated arrangement of pulleys for gaining a high speed of rotation at once, without intermediate pulleys, is shown by Parker's patent belting in Fig. 2.

In this the auxiliary pulley B is connected to the driven pulley C by an endless belt, F F, but, unlike the usual method, the driving pulley A is set against the outside of the belt to contact with B and C, the belt passing between.

Fig. 2.



The axis of the pulley B turns in the ends of the arms E, one being on each side, which are jointed with the arms D, at H, outside the pulley, the other ends of D turn upon the shaft bearings of pulley A.

These levers form a toggle by which the auxiliary pulley is forced against the driving pulley. The effect of this combination is to draw belt and pulleys into close driving contact, and at the same time to avoid severe lateral strains on the shaft bearings.

The driving and driven pulleys may have diameters of 30 to 40 and even as high as 50 to 1 respectively, the driven pulley may, indeed, be nothing more than an enlargement of its shaft, and the auxiliary pulley must be of such diameter as will prevent contact of belt at F.

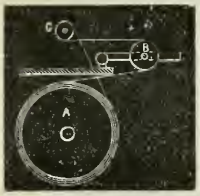
The pulley surfaces must all be straight, that of C may be covered with leather, the belt must be made of well stretched leather of uniform texture, must have a permanent joint and be of equal thickness throughout its entire length, and all the parts must be fitted with great exactness to insure perfect working of the combination.

Many of these have been made and used for driving small circular saws, where hand power is employed, and for such and like purposes they answer very well.

One of the simplest methods of increasing the efficiency of any belt or cord is with pulleys of given dimensions, to cause it to embrace a greater portion of their circumference, which increases proportionally its adhesion as well as its driving power. The following shows one method of doing this by the cord and pulley arrangement.

In Fig. 3 one fold of the cord is drawn out of its direct course between the peripheries of the driving sheave A and driven sheave C across the other fold and around a tightening sheave B, which is so arranged as to be moved to and from the other sheaves and set at such an angle as to prevent contact of cords at points of crossing. The movement of B is such as to permit the cord to run in grooves of different diameters on A and C, by which different speeds in C can be obtained when that of A is uniform.

Fig. 3.



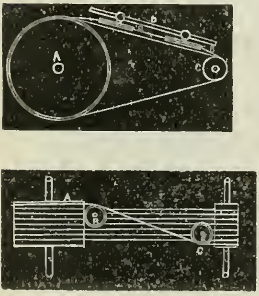
This is an old device and is frequently applied to the driving gear of foot lathes.

In this the driving power is limited to the adhesion of the single cord in the sheave grooves, but its circumferential contact is such as to give the greatest effect possible.

In order to greatly increase the adhesion of the cord the plan shown in Fig. 4 has been devised and consists of two multigrooved wheels A and C, the driving and driven sheaves of the system. Into the grooves of these sheaves is wound continuously a single endless cord, in parallel lines from one sheave to the other, such that the cord in leaving the last groove of A is deflected across and above the other cords and delivered in line of the groove in C by the adjustable single grooved sheaves B and B.

The bearings of these sheaves are secured to rods D D fixed parallel with the cords and upon which the sheaves can be slipped and fastened to take up slack of cord.

Fig. 4.

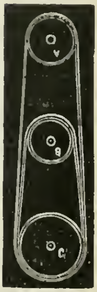


It is evident that with any cord its adhesion, and consequently its driving power, is increased in the direct proportion of the number of grooves in each driving sheave.

Referring generally to pulleys with angular grooves for round cords of any material, we quote from *Publication Industrielle par Armengaud ainé*, Vol. IX. p. 428.

"This system is much in use for transmitting power by means of hemp cords or round gut belts of small dimensions. The angular shape of the groove is preferred in order to increase the adhesion of the cord which is thus pinched between the surfaces of the groove by the primitive tension it receives similar to ordinary belts. The angle which the two surfaces form with each other is made ordinarily 60°"

Fig. 5.



A very simple method of driving two pulleys on separate shafts from one pulley is shown in Fig. 5. The driving pulley A has a belt running to B, which it turns in the usual way.

The pulley C may be driven by A also, by simply running its belt over the belt which turns B.

The belts atop of each other on A increase the adhesion sufficiently to drive both B and C.

We have found it convenient as well as economical to resort to this expedient for driving lines of shafting in different stories from the prime mover below.

(To be continued.)

Rusting of Iron.—Dr. Calvert, a fortnight ago, communicated to the Chemical Society some very useful information on the rusting of iron. Rust is mainly sesquioxide of iron, and it has always been supposed that the active agents in producing it are moisture and oxygen. It seems, however, from Dr. Calvert's experiments that carbonic acid must be associated with these to produce any considerable amount of oxidation. In dry oxygen iron does not rust at all; in moist oxygen but little and seldom; but in a mixture of moist carbonic acid and oxygen iron and steel rust very rapidly. In like manner a piece of bright iron placed in water saturated with oxygen rusts very little; but if carbonic is present as well, oxidation goes on so fast that a dark precipitate is produced in a very short time. Curiously enough, bright iron placed in a solution of caustic or carbonated alkali does not rust at all. These facts show that the points to be attended to in the preservation of iron from rust are the exclusion of carbonic acid and moisture, two indications which may be very easily fulfilled.—*Chemical News.*

BRIDGE CONSTRUCTION.

By Col. W. E. Merrill, U. S. N.

There are some points in the review of my recent work on "Truss Bridges," published in this *Journal* for February, 1870, which I think demand reply, and as the reviewer has, in some points, misunderstood the object of my work, and my reason for going into certain elaborations, which I agree with him in considering unnecessary in practical construction, I am glad to be able to avail myself of the opportunity for re-stating my object and views.

My object was not in any way to deal with the details of making the parts of a bridge, which pertain rather to mechanical than to civil engineering, but simply to discuss the problem of *form*—to endeavor to ascertain, by calculation, *which* method of combining chords, posts and braces would give the best results—or, in other words, would necessitate the use of the least amount of iron to carry with a given degree of safety a given moving load. To do this it became necessary to take each well known form of bridge and calculate the weights of each one of its parts with the utmost nicety, assuming for each one of the trusses examined the same permanent and rolling load, and the same general dimensions.

To do this, with justice to all, I was necessarily led into many refinements of calculation which in ordinary cases are entirely unnecessary; such as the "extra strains," and for some spans, the subdivision of the rolling load.

It is well known that when a long pillar is loaded with a weight acting through its axis it breaks by flexure under a strain much less than the crushing weight of its cross section. It commences to bend under a still smaller weight. The moment this begins it becomes, as it were, two pillars making a very obtuse angle with each other, held together by molecular cohesion. Every pound of additional weight gives necessarily a transverse component at the point of flexure, as well as a component through the lower half of the pillar, neutralized by its support. Manifestly if we can hold the pillar in any manner at the point of flexure so as to neutralize this transverse component, and prevent it from acting on the pillar, we very greatly increase its capacity to withstand a strain through its axis. If this pillar were composed of a number of small pillars fastened together, no matter in what way, this tendency to flexure would still exist. But the top chord of a Bridge, with the strains through its axis, presents an analogous case, with the additional unfavorable transverse action of its own weight. The chord, therefore, must naturally sag somewhat, and no matter how carefully the mechanical connections are made, as it is impossible to keep the segments in a strictly accurate line, there must be generated transverse strains at the joints of the series. If this were not the case why is it necessary to have top lateral bracing? Parallelism of the trusses could be secured by connecting the end posts, were there not deflecting agencies to be guarded against at other points. Universal practice in construction recognizes the existence of these abnormal horizontal strains. It seems, therefore, an inevitable conclusion that the abnormal vertical strains should be recognized also. How to estimate for them is a different matter, and after long and patient study and investigation, I could decide upon no better or simpler method than that given in the text.

Experience has shown that in the Bollman bridges it is absolutely necessary to introduce panel ports and ties which form no part of the weight bearing system. The theory which I have adopted accounts for their use and necessity, and gives an approximate means of estimating their sizes. Knowing them to be essential in this bridge I was necessarily led to examine into the need of something similar in other bridges. The calculations show that in most others these "extra strains" are, in the main, provided for by the ordinary posts and braces. But as a matter of justice to all I was compelled to take these strains into account wherever they added even a pound to the maximum direct strains on any principle member. Though I admit freely that in most cases such a discussion is an unnecessary refinement, I yet must insist that in a *comparison* as to economy in combination it is imperative to take everything into account that can effect the result. I thought that my opinions and reasons on this matter were all set forth with sufficient clearness in the work itself, but as the reviewer seems to have failed to appreciate my argument I hope that this explanation may be of service to him. As to the size of top chord selected for computing these extra strains, I am aware that I exaggerated somewhat, but I considered it best to do so in order to provide fully for shocks and vibrations that cannot be brought down to exact calculation.

The "mathematical jugglery" referred to in the review is simply the necessary transposition of terms in Hodgkinson's formulæ in order to obtain, in the shortest time and simplest manner, the values of the *diameter*, which in bridge calculations is necessarily the unknown term. Hodgkinson's formulæ only show how to find the breaking weights of *given* pillars; but in bridges this breaking weight, which is the maximum strain increased by the factor of safety, is a *known* term, as is also the length. It is, therefore, an absolute necessity that the equations be solved with reference to d, the unknown term and quantity sought. In the case of short pillars the difficulty in obtaining d is still further increased by the use of his formulæ. It is true that when d is given and W is sought these formulæ are of easy application, but when the reverse is the case d can only be obtained by a series of approximations, unless the equations are combined and a single equation deduced for the value of d. This simple and necessary work seems to have bewildered the reviewer, and, therefore, he contemptuously styles it "jugglery." This is certainly a strange term to use in a serious review of a professedly mathematical work.

The reason why I made use of the round-end formula in calculating compression strains is fully stated in the work. According to Hodgkinson the strength of a flat end pillar, not immovably fixed, is about one-third of what it is when the ends are so secured that no motion whatever can take place. Posts and Top Chords in bridges, however accurately the connections are made, are subject to vibrations and small movements, and therefore are not proper cases for the use of the flat-end formula. It is a matter of choice whether we should use the flat-end formula, divided by three, or adopt the round-end one, which gives exactly the same result. Bearing in mind that my object was only to institute a comparison for the purpose of ascertaining the merits of the different combinations it seemed immaterial which course I had better follow, and, therefore, I chose the one that seemed simplest—using the same formula in all cases.

I am quite willing to concede that "ordinary engineering calculations do not require astronomical accuracy," but the reviewer should have borne in mind that I was not making an ordinary engineering calculation, but a *comparison*, and therefore was compelled to take everything into account that could effect the result. I have used logarithms freely in order to insure accuracy, and because Hodgkinson's formulæ cannot be used without them; and I cannot believe that any good engineer can afford to neglect so great an assistance, or can find any difficulty in its use. At all events railroad engineers who are daily using logarithmic sines and tangents can hardly object to logarithms of numbers. I have been very careful in the tables to give both the actual numbers and the logarithms of all constants, in order to facilitate as much as possible the use of the formulæ.

The nomenclature of the trusses examined is but a small matter at best. It was necessary to name them for convenience of reference, and I used my best judgment in choosing the designations adopted. If I have, unintentionally, done injustice to any bridge builder I regret it; but as the trusses themselves are carefully drawn in outline, those disliking the titles which I have chosen may give them such others as may seem to them more fitting.

I am aware that the Fink and Bollman bridges are better as deck than as through bridges, and I have so stated; but as from necessity the great majority of R. R bridges are overgrade I did not deem it necessary to make a special discussion of undergrade bridges.

The only really important objection that the reviewer has advanced is that to my manner of treating the counter. But while he objects to my conclusions, and quietly states that there can be no question as to the true use and action of this member, he neither refers to the proofs which I have alleged, in favor of my view, nor gives any himself. I am fully aware that many high authorities on bridge building are on his side, but the assumption that *all* are, and that there is but one opinion on the point involved, is gratuitous and inaccurate. The point is *not* a conceded one, and if it were he should have been able to point out the error in the course of reasoning by which I apparently proved the contrary. I have endeavored to prove every step which I have taken, and also to express these proofs so clearly that no one could misapprehend my meaning. The natural inference is that the reviewer could not successfully attack my demonstrations, or else that he examined the book so carelessly as not to have noticed them.

In reference to the use of cast iron for compression I have simply expressed my individual preference. The strongest reason for my choice of it in making the comparison as to economy in combination, arose simply from the fact that cast-iron compression members can more readily be calculated from formulæ than similar parts of wrought iron. The latter depend for strength so much on mechanical skill and peculiarity of combination, that the only sure dependence on them comes from experiment. I doubt if a formula could be found that could give, with any reliability, the comparative strengths of the different posts and chords in use. Moreover the object of the treatise was not to discover which bridge building company had succeeded in getting the best posts and chords to sustain given strains, but to ascertain which would have the least strains to meet, and which, therefore, ought to be able, with a given amount of metal, to make the strongest bridge. The test of this point simply required perfect conditions of equality—and, it was believed, that such equality could best be secured by assuming cast iron compressive members. The reviewer refers, occasionally, to Mr. Shale Smith's pamphlet, in terms of commendation. If he will examine it, carefully, he will there find that Mr. Smith has spoken much more decidely of cast-iron than I have.

The competition for the Quincy bridge is adduced as showing, from the builders themselves, a different estimate of weights from that which I have deduced. This is begging the question, as there is nothing to show that the three bridges had the same strength. The bidders may have over-estimated or under-estimated the strains which they were to provide for. The comparative statement is of no value at all unless it be shown conclusively from calculations made by the same Engineer, that the three bridges were equally strong throughout. Comparing the bids with my own calculations for the same span, I can only conclude that Mr. Post would have built the strongest bridge.

Finally, I would like to add a few words about the object and purpose of my work. I do not claim it to be exactly correct, but simply that it is correctly reasoned to the best of my ability. Bridge building, as a science, has improved greatly within the last few years, and it is to be presumed that it will continue to improve. Until it reaches perfection it is the bounden duty of all engineers to contribute what they can to clear up any dark points. By combining the studies and knowledge of many, some clearing up one obscure point and some another, though no one author may be right throughout, yet those that come after can gather up the scattered truths and build up an harmonious and correct system. Believing this I have given my little work to the world, not as finally conclusive on the subject of truss bridges, but simply as my individual contribution. That it would meet with hostile criticism I expected, but I hardly looked for so *ex-parte* and thoroughly prejudiced a review as that which has called forth this reply. The best points in the work are quietly ignored and much ado is made about preface and bridge titles, things in themselves of little importance, and of no bearing on the general result. I gladly invite criticism, and hope that much good, to myself and others, may arise from the full discussion of the points at issue—but I hope that the next reviewer may come to his task without a mind as evidently made up in advance, and so determined to see nothing good in the work. I have prepared this answer to the reviewer more because of the influence and character of the *Journal* in which his critique appears, than on account of anything in the article itself.

Stone Marbles and how they are made.—The chief place for the manufacture of "Marbles" is at Oberstein, on the Fahe, in Germany, where there are large agate mills and quarries, the refuse of which is carefully turned to good paying account, by being made into small balls employed by the experts to knuckle with, which are mostly sent to the American market. The substance used in Saxony is a hard, calcareous stone, which is broken into blocks nearly square by blows with a hammer. These are thrown by the one hundred or two hundred into a small sort of mill, which is formed of a flat stationary slab of stone, with a number of concentric furrows upon its face. A block of oak, or other hard wood, of the same diametric size, is then placed over the small stones and partly resting upon them. This block or log is kept revolving while water flows upon the stone slab. In about fifteen minutes the stones are turned to spheres, and then being fit for sale are henceforth called "marbles." One establishment, containing only three of these rude mills, will turn out fully sixty thousand "marbles" in one week. Agates are made into "marbles" at Oberstein by first chipping the pieces nearly round, with a hammer, handled by a skillful workman, and then wearing down the edges upon the surface of a large grindstone.

Preparation of Pure Oxygen Gas at the Ordinary Temperature.—By Prof. Boettger. The author says that when a mixture is made of equal parts, by weight, of peroxide of lead and peroxide of barim, and there is poured on this mixture dilute nitric acid of a strength of 9° Beaume, and specfic gravity 1·069 a current of pure oxygen, free from ozone and antozone, is given off abundantly. This mixture of the two peroxides alluded to may be kept together in a stopped bottle, in dry state, for any length of time.—*Dingler's Polytechnic Journal.*

Mechanics, Physics, and Chemistry.

A NEW MECHANICAL FINGER FOR THE MICROSCOPE.

By J. Zentmayer.

At the present time, when we are informed almost daily of some new scheme of gigantic magnitude, and while nothing short of connecting two worlds or two oceans, by Cable, Canal or Railroad, will create even a short lived excitement, it may hardly seem profitable to call attention to a Lilliput Engineering Instrument, such as the *Mechanical Finger.* But, on the other hand, while some far-sighted ones already fear that this cutting through Isthmuses, tunneling mountains and mining whole kingdoms, might, before long, dangerously displace the centre of gravity of our earth, I can, at least, promise faithfully, that even if the instrument which I am about to describe is worked to its utmost capacity it will not appreciably disturb the equilibrium of our planetary system.

In the study of diatoms it has been long desired to find a substitute for the clumsy fingers of the human hand, to do the delicate work of picking up rare and valuable diatoms detected by the microscope and to transfer them to a glass slide for preservation.

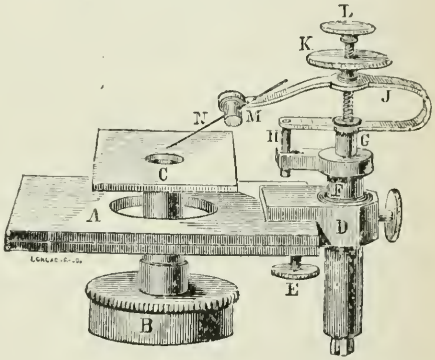
Prof. H. L. Smith, well known by microscopists as the inventor of several valuable accessories to the microscope, first presented us with a very ingenious little instrument of this kind.

Messrs. John H. B. Latrobe and Geo. Dobbin of Baltimore, two expert microscopists, had in use for some time one of these instruments, but found it difficult to work it; and as the instrument was exceedingly well made, this proved that its construction was too complicated to give the firmness required in picking up a shell, less than the thousandth part of an inch in length, and of which a single ounce of ocean sand contains, sometimes, many millions. Mr. Latrobe invited me to design and construct for him an instrument for this purpose.

The instrument requires many adjustable movements, and each of these increases its liability to shake and spring. So I made it my object to utilize such movements of a first class microscope stand as are not essential for other specific operations, as parts of the new finger. I found in the movements of a mechanical or sliding stage the main movements required in the finger, and so attached the apparatus to the mechanical stage. This gave me two of the most important movements, with a firmness and with dimensions of parts for which, otherwise, there would be no room.

This step, however, made it necessary to provide for another stage; but as there is never a higher power than a $\frac{2}{3}$ employed with such an apparatus, a plain stage with some simple arrangement to hold the slides would be found quite sufficient. Such an one was therefore arranged. The cut represents the finger attached to one of my large microscopes.

A is the top plate of the mechanical stage; the circular plate is omitted. The cap B is fitted to the lower body below the stage, into which cap the new sub-stage C is fastened by a narrow tube, wide enough to admit illumination from the mirror. As the lower body is movable up and down by a rack, another movement is gained which is necessary to accomplish our result. The difference of the size of the aperture of the stage and the diameter of the tube, which connects the sub-stage with the cap A is equal to the movement of the mechanical stage, and this is found more than sufficient.



D is the clamp by which the finger is attached to the stage by means of the screw E. A steel cylinder, G, is nicely fitted into the top and bottom of the tube F, leaving room inside for a light spring to press the steel cylinder upwards. To prevent turning, the spring I is provided, at H, with a steel pin, accurately fitted into the fork at the top of the tube F. By turning the nut K the spring I is elevated and depressed, giving nice adjustment to the needle N in case the finger is to be attached to a microscope, not having rack-movement to the cap B, to bring the end of the hair and the object in close approximation.

The end of the spring I forms a little ring, with a screw cut inside, into which a cork M is screwed to receive a needle N, to which a hair is fastened by wrapping gum-paper around. Turning the cork facilitates the adjustment of the hair to the proper inclination. A slight pressure on the button L brings down the hair, and the spring, inside of F, instantly lifts it again when the pressure is removed.

The tube F turns in the clamp D in order to adjust the hair and cork more conveniently, and when brought back again it is tightened by a set screw.

Complicated as it may appear, only one movement is added to the microscope stand by this instrument, the one, namely, which gives the vertical motion. When the apparatus is to be used the material you want to select from is placed on the sub-stage C and focussed, then the point of the hair is approximately brought over the selected object by means of the stage movements and turning of D; this brings the hair nearly in focus too, because it is almost in the same plane with the object. We next adjust the hair precisely over the selected shell, press down the button L, and the shell will adhere to the hair. Now we remove the slide with the material and substitute a glass slide, moistened by breathing on it, and having brought it in proper position, briskly dip down the button L again and the shell will be deposited on the glass slide. As the mechanical stage has a graduated indicator, the finger may be moved along regularly, and shells may be placed at equal distances in lines. After the cover-glass is carefully placed over it, then Canada Balsam may be run in by capillary attraction without disturbing the position of the shells.

Philadelphia, April, 1870.

Extraction of Zinc from its Ores in the Wet Way.—A method of extracting zinc from the most common of its ores, calamine, (the carbonate,) in the moist way, has been devised and published by Jungmann. If practised on a large scale the operations would no doubt involve greater expense and trouble than the mode of reduction commonly adopted, but the metal obtained would certainly be purer, and probably the yield larger. The plan consists in first boiling the calamine with a strong solution of chloride of calcium. In this way there is obtained by a double decomposition a solution of chloride of zinc, while carbonate of lime is precipitated. The solution of chloride of zinc is next run off and treated with lime, whereby chloride of calcium is reproduced and oxide of zinc precipitated. The oxide is then reduced and the metal distilled in the ordinary manner. The only recommendation of this process that we can see is the possible greater purity of the metal obtained, which is, however, a matter of no great importance.

INVESTIGATION OF FLAME TEMPERATURES; IN THEIR RELATIONS TO COMPOSITION AND LUMINOSITY.

By B. Silliman and Henry Wurtz.

FIRST MEMOIR.

CALORIFIC POWERS OR EFFECT OF GASES.

[Read to the American Association at Salem, August, 1869.]

These subjects lie, in our belief, at the very basis of the true theory of the phenomena of luniferous gases, and have practical bearings that can scarcely be overrated.

In fact, our studies of the subject have led us in the direction of the general conclusion that, all other conditions being equal, the *temperature*, in a given flame, is the main factor of luminosity. This, however, may as yet be regarded merely as an hypothesis; in consequence of the imperfection of our present means of actual experimental demonstration of the temperatures of flames. It is an hypothesis, nevertheless, which is in general accordance with known facts. By the spectroscope, for example, which can recognize only luminous rays, we find that the higher the temperature the greater the number of these luminous rays. The recent results of Frankland upon the development of luminosity by increased pressure, in flames which are non-luminous under atmospheric pressure, are in accordance with this view; increase of temperature necessarily following increase of pressure.

Very vague views have been rife, even among chemists, with regard to the temperatures of luminiferous flames. Some have been satisfied with believing crude hypotheses; such as that the heat power of a flame is always proportional to the *density* of the gas or vapor undergoing combustion; or that it is proportional to the *amount of oxygen consumed* by a given volume of the gas, and so on. This latter hypothesis has been one of very common acceptation. A view which is even now entertained by some skilful chemists (than which, however, nothing, as will be shown below, could be more fallacious) is, that those individual gaseous compounds which impart the highest luminosity under ordinary conditions, are also the most productive of heat.

The admirable researches of the great gas-chemist, Bunsen of Heidelberg, placed in our possession some years ago the means of computing, at least with approximate accuracy, the heat of flames of gases of known compositions. Few however have properly and successfully applied Bunsen's methods in practice. We consider it quite time that these methods should be introduced to the knowledge of Gas Engineers, in forms available to them.

Bunsen's *formulæ* for these computations are based upon the actual experimental determinations of the *total* amounts of heat developed by the combustion of different pure combustible gases with pure oxygen, made by Favre and Silbermann: and upon Regnault's determinations of the specific heats of gaseous products of combustion.

It is not to be maintained that Favre and Silbermann's numbers are strictly correct, but they are doubtless approximate, and at least proportionally correct among themselves. At any rate, they are the best data we have. Those employed here are included in the following table. They are usually given in the text-books for equal *weights* of the gases, but we have reduced them to the standard of equal *volumes* also, as more suitable to our present purpose. This reduction is made simply by multiplying the equivalents for weights, by the densities as given in the third column.

TABLE I.

	TOTAL CALORIC EQUIVALENTS.		DENSITIES on Scale of Hydrogen = 1.
	Of Equal Weights	Of Equal Volume.	
Carbonic Oxide	34,462° C.	34,462° C.	1·
Hydrogen	2,403° "	33,642° "	14·
Marsh Gas	13,063° "	104,504° "	8·
Olefiant Gas	11,858° "	166,012° "	14·

The meaning of this table is simply that equal weights of water would be heated by the several gases to temperatures proportional to the numbers in the first column, when equal *weights* of the gases are burned; and proportional to those in the second column, when equal *volumes* are burned.

A cursory glance at the figures in the second column of this table might seem to justify the notion hitherto entertained by many of the comparatively low calorific powers of hydrogen and carbonic oxide; and it was doubtless as a consequence of such a comparison as this that statements have been put forth and widely accepted among American Gas Engineers to the effect that the weight of water heated from the freezing to the boiling point by one cubic foot of the four main components of illuminating gas, respectively, is as follows:

Hydrogen	2·22	lbs.	water.
Carbonic Oxide	2·16	“	“
Marsh Gas	6·17	“	“
Olefiant Gas	10·74	“	“

The figures here being obviously about in the same ratio as those in the second column of Table I. Several most grave errors, however, are here involved. To get at the true relative calorific effects of the above gases, when burned in the open air, in heating water, below its boiling point, deductions must be made, not only for the *specific heats* of the products of combustion of the gas, but also, more important still, for the specific heat of the *nitrogen of the air* required to burn the gas. In fact, when we consider that for each volume of oxygen required to burn a given volume of a gas, about *four volumes* of nitrogen must be heated up to the temperature of the flame, it becomes easy to conceive, what is actually the fact, that within certain limits the waste of heat due to this cause alone counterbalances altogether the advantage that would be supposed to result from the crowding of combustible matter into so condensed a form as in the illuminating hydrocarbons. An inevitable result of our investigations of this matter, is that the heating powers of the flames of pure hydrogen and pure olefiant gas, even when used to the greatest advantage, to heat water below its boiling point, are almost or quite identical.

In this discussion we have occasion to use the numbers representing the specific heats of but *three* gases, the three, namely, which remain after complete combustion, *steam*, *carbonic acid* and *nitrogen*; as we must assume that in the hottest and most luminous zone or shelf of the flame, there is no oxygen in excess to be heated. These three numbers are, according to Regnault's latest determinations for equal weights of

Steam	0·4805
Carbonic Acid	0·2163
Nitrogen	0·2438
(*Liquid water* being	1·0000)

This means that the amounts of heat which would raise one pound of water and steam *to the same degree* are in the ratio of 0·4805 for the pound of steam, and 1 for the pound of water.

Calculation of the Calorific Effect of Hydrogen Burning in Air.

Let us take, first, the simplest case possible, that of hydrogen with exactly the right admixture of pure oxygen to burn it, which, by Table I, develops a total heat of 34462° C; that is, would heat a certain weight of *liquid* water to this temperature. In order to find the actual amount of heat contained in the products of combustion, we must first take into account the fact that one pound of hydrogen burns to *nine pounds* of steam, and then obtain the ratio between the above number, 34462, and the amount of heat necessary to heat nine times the weight of steam; that is, nine times the specific heat of steam. Calling the total residual heat in the produced steam x, we have the simple proportion:

$$9 \times (\text{Sp. heat of steam} = 0{\cdot}4805) : 34462 :: (\text{Sp. heat of water} = 1) : x;$$

$$\text{or, } x = \frac{34462^\circ}{4{\cdot}3245} = 7969^\circ \text{ C.*} = 14376^\circ \text{ F.};$$

a number which, we may add, represents the *maximum* of heat capable of being imparted to *liquid water* by the flame of Hare's oxyhydrogen blow-pipe.

Still, we have by no means here the actual temperature of the free or open flame of Hare's blow-pipe; which is generally *lower* than this figure, as we have not yet taken into account the "latent heat," or heat of vaporization, of the 9 lbs. of steam formed. The centigrade temperature necessary to convert 1 lb. of water into steam being 537°; to get the *actual temperature* of the oxyhydrogen flame, we must modify the above equation, so that

$$x = \frac{34462^\circ - (9 \times 537^\circ)}{4{\cdot}3245} = 6851^\circ \text{ C.} = 12364^\circ \text{ F.};$$

which is the temperature actually possible in the flame of the compound blow-pipe, *were the combustion instantaneous and complete.*

When hydrogen gas burns in *air*, however, as has been before stated, another deduction of enormous amount must be made from the above figures, due to the heat required to expand the nitrogen. This is obtained simply by adding to the divisor, as above, the weight of the nitrogen of the air employed, multiplied by its specific heat. The weight of the nitrogen in air = 3·318 times the oxygen; so that the latter of the above equations becomes

$$x = \frac{34462^\circ - (9 \times 587^\circ)}{4{\cdot}3245 + (8 \times 3{\cdot}318 \times 0{\cdot}2438)} = 2744{\cdot}5^\circ \text{ C.} = 4972^\circ \text{ F.}$$

[We have here a full explanation of the extraordinary rate of degradation of illuminating gas by admixture of air, which we have discussed elsewhere. The nitrogen of such air is not merely a dilutent, or even a mere deductive quantity; its specific heat is an actual *divisory* function in diminishing the flame temperature.]

This, then, is the actual temperature to which the flame of hydrogen gas burning in the atmosphere might attain to, supposing complete and instantaneous combustion. If it is desired to obtain instead, the total calorific effectiveness, as in heating water below its boiling point—in which case the latent heat of the steam of com-

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*Bunsen, in his *Gasometry* (English edition of 1857, p. 242), gives this number as 8061° C., the difference being due to the use by him of a different number for the specific heat of steam, namely, 0·475, apparently an earlier determination of Regnault. Bunsen makes here the singular oversight of regarding this figure as the temperature, when "the gases can freely expand, as is the case in an open flame," overlooking the correction necessary in this case for the *latent heat of steam of combustion*, as is explained in the text above.

bustion becomes also available—the above expression is changed by simply omitting the subtrahend in the numerator:

$$x = \frac{34462^\circ}{4\cdot3245 + 6\cdot4714} = 3192^\circ\ \text{C.} = 5778^\circ\ \text{F.}$$

Calculation of the Calorific Effect of Carbonic Oxide Burning in Air.

As the product of combustion is here solely carbonic acid, no latent heat of steam enters, and the calorific effectiveness is the same, under all circumstances, in air. In the numerator we substitute, of course, the calorific equivalent of one volume of carbonic oxide from table I.; and in the denominator, for the specific heat of 9 pounds of water, that of 22 pounds of carbonic acid, being the weight of the latter formed by the combustion and combination of 14 lbs. (weight of a volume of carbonic oxide on the hydrogen scale by third column of Table I.) of carbonic oxide, with 8 lbs. of oxygen. The number for the specific heat of nitrogen is the same as before; and the equation is now

$$x = \frac{33642^\circ}{(22 \times 0\cdot2163) + 6\cdot47 = 11\cdot23} = 2996^\circ\ \text{C.} = 5425^\circ\ \text{F.}$$

Marsh Gas and Olefiant Gas.

In these two cases, we have as products of combustion both carbonic acid and water; and, therefore, when the calorific effects are sought for, we have not only the latent heat of steam entering as a subtrahend into the numerator, but also into the denominator, as divisors, all three of the specific heats of steam, carbonic acid and nitrogen.

Then, as 8 lbs. of marsh gas consume 22 lbs. of oxygen, and produce 22 lbs. of carbonic acid, and 18 lbs. steam; and as 14 lbs. of olefiant gas consume 48 lbs. of oxygen, producing 44 lbs. of carbonic acid, and 18 pounds of steam, the equations for the calorific powers of their flames in air become—

For marsh gas:

$$x = \frac{104504^\circ - (18\cdot \times 537^\circ)}{(18 \times 4805) + (22\cdot \times \cdot2163) + (32\cdot \times 3\cdot318 \times \cdot2438)} = 2414^\circ\ \text{C.} - 4386^\circ\ \text{F.}$$

And for Olefiant gas:

$$x = \frac{166012^\circ - (18 \times 537^\circ)}{(18\cdot \times \cdot4805) + (44\cdot \times \cdot2168) + (48\cdot \times 3\cdot318 \times \cdot2438)} = 2743^\circ\ \text{C.} = 4970^\circ\ \text{F.}$$

When the deduction for the latent heat of the steam of combustion is not made, the results in these two gases are considerably higher, as will be obvious from mere inspection of the formulæ.

We shall now give, in tabular form, all the results of our calculations of the calorific powers when burning in the air, of the four gases we have to deal with.

TABLE II.

FOR EQUAL VOLUMES OF THE GASES BURNING IN AIR.		Calorific Effects in Heating Liquid Water		Calorific Effects Above 100° C.	
		Centigrade Degrees.	Fahrenheit Degrees.	Centigrade Degrees.	Fahrenheit Degrees.
Hydrogen	(Sp. Heat HO =·4805)	3192°	5778°	2744°	4971°
	(Sp. Heat HO =·4750)	3204°	5799°	2755°	4991°
	Mean..........................	3198°	5788°	2749°	4980°
Carbonic Oxide..............................		2996°	5425°	2996°	5425°
Marsh Gas, (Sp. Heat HO=·4805)..		2660°	4820°	2414°	4386°
Olefiant Gas " "		2916°	5481°	2743°	4970°

Computation of Calorific Effects of Mixed Gases.

The above Table renders the calculation of the calorific effects of any given gaseous mixture, whose centesimal composition is known, a matter of extreme simplicity. It is only necessary to obtain the sum of the multiples of the percentage of each component gas into its calorific capacity, as given in the Table, and divided by 100.*

To serve as examples of these modes of computation we here cite, in tabular forms, the results of some analyses of a number of gaseous mixtures, made by us during the past winter (1868-69.) [These analytical results, it may be remarked, possess points of novelty and importance, both scientific and practical, which will bring them up again hereafter, in other connections. They are here placed on record.]

Table III. gives the results of two analyses of gaseous mixtures obtained by passing steam *superheated to incandescence* upwards through a mass of *anthracite coal* heated to a high degree in a clay retort of a novel construction, according to what is now known as the "Gwynne-Harris," or American Hydrocarbon Gas System. In

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*Prof. Bunsen, in the masterly discussion of the subject, presented in his *Gasometry* not having in view the exact object we propose, has used a train of reasoning and a mode of formulation of some complexity, to follow which requires some little mathematical skill—part of his objects having been to construct a *formula* so general and comprehensive as to cover the direct computation, from any gaseous mixture independently, of its special calorific intensity. We have here aimed at so simplifying as to bring the whole subject within the capacity of all. Our above tabulation of the individual gaseous components, as a starting point, seems to us to accomplish this most effectually, so far as illuminating gases are concerned.

this table the results are calculated without carbonic acid and sulphuretted hydrogen, which, with traces of nitrogen and sometimes of oxygen, are found in the unpurified anthracite gas.

TABLE III.

ANALYSES OF ANTHRACITE HYDROCARBON GAS.—BY SILLIMAN AND WURTZ.

	No 1.	No. 2.	Mean.
Hydrogen	60·43	59·32	59·87
Carbonic Oxide	35·44	37·14	36·29
Marsh Gas	4·13	3·54	3·84
	100·00	100·00	100·00

In Table IV. column 1 gives the results of the analysis of the street gas served out at this period by the New Haven Gas-Light Company; made from Westmoreland coal enriched with about six per cent. of Albertite. Column 2, the mean of four analyses of the completed hydrocarbon gas made by us at Fair Haven during the same time, by combining gas from the same Westmoreland coal (with 10 per cent. of Albertite) with half its volume of the Anthracite gas. Columns 3 and 4 are obtained from 1 and 2 by centesimal reduction, after deduction of the illuminant ingredients, being what we propose to designate as the non-illuminating *substrata* of illuminating gases.

TABLE IV.

GAS ANALYSES—BY SILLIMAN AND WURTZ.

	(1.) New Haven City Gas.	(2) Fair Haven Hydrocarbon Gas.	(3.) Substratum of New Haven Gas.	(4.) Substratum of Fair Haven Gas.
Hydrogen	43·58	46·77	46·79	50·27
Carb. Oxide	2·14	9·56	2·31	10·27
Marsh Gas.	47·42	36·71	50·90	39·46
Illuminants	6·86	6·96		
	100·00	100·00	100·00	100·00

Table V. gives the results of the computation, from our *formulæ*, of the calorific powers of these five gaseous mixtures, for communicating temperatures both above and below that of aqueous ebullition. We should remark that we have been obliged to regard the volumes of *illuminant hydrocarbons* as representing olefiant gas solely; both because we have no certain data as to their real nature, and particularly because, if we actually knew, or should assume, the nature of the hydrocarbon vapors present, still we have no experimental calorific equivalents, as we have for olefiant gas, from which to start, in such a computation. We have reason to believe nevertheless that the errors thus introduced are not important in amount.

TABLE V.

	Weights of water equally heated below boiling; by equal volumes.	Weights of water Equally heated above boiling; by equal volumes.	First column reduced to New Haven Gas=100.	Second column reduced to New Haven Gas=100.
Anthracite Gas	3100	2828	104·2	109·2
Substratum of the New Haven Street Gas	2917	2581	98·1	99·6
Subtratum of the Fair Haven Hydrocarbon Gas	2962	2640	99·6	102·0
New Haven Gas; with the illuminants assumed = Olefiant	2974	2592	100·0	100·0
Fair Haven Gas; with the illuminants assumed = Olefiant	2959	2647	99·5	102·1

Conclusions.

Some of the practical conclusions to which we are of necessity compelled, by the results of the above investigations, are somewhat remarkable, so that we feel diffident regarding them. It is, however, always safe to follow the leading of Truth, however astray she may conduct us from our preconceived notions.

From Table II. it is apparent:

1. That of all known gases, the highest calorific effects, under ordinary atmospheric conditions are obtainable from *carbonic oxide;* whose calorific value, above 100° C., is about 3000° C.

2. That in absolute calorific value, below 100° C., in the atmospheric medium, *hydrogen* surpasses its volume of any other gas; giving a temperature of about 3,200° C.

3. That for all modes of application—that is, for producing both high and low temperatures—the total maximum calorific effectiveness of carbonic oxide is a *constant quantity.**

4. Compound condensed submultiple volumes of hydrogen, like that in marsh gas, have much *less* total calorific value in air than their volume of free hydrogen.

5. Condensed compound submultiple volumes of gaseous carbon, like that in olefiant gas, have no greater total calorific value in air, below 100° C., than their own volume of carbon gas in the form of carbonic oxide; while above 100° C. their value is even considerably less.

THE FIRE ALARM TELEGRAPH OF NEW YORK CITY.

The Fire Alarm Telegraph is designed, first, to enable any person to send a quick, reliable telegraph message to the Central Station, indicating the existence of a fire near the spot from which the message is sent; and, secondly, to enable the receiver of such a message to report instantly to as many other stations (the most important of which of course is the engine houses) as may be deemed advisable.

It is essential to the useful working of such a system that it should be always ready to respond instantly to the demands upon it; that the message sent should be positively reliable; that the condition of the out-door structure should at all times be under complete inspection of the Central Office; that an ordinary injury to the out-door structures may be instantly known and quickly repaired; that this injury, if not very extensive, may be of no serious detriment, and that a printed record of the transactions of the day, and the fidelity of those in charge, shall be produced. Such are the requirements of a perfect Fire Telegraph. How they are met will require an explanation in full detail of the construction, the machinery and their varied combinations.

Lines.

These are so built that only a few stations are embraced in each, and they are so interwoven that contiguous stations are upon different lines, so that an injury to one line, which might put one station out of order, would have no effect upon the next nearest station—because that one would be placed in connection with a distinct and separate line. The wires are very strong, and of unusually high conductivity, so that the currents of electricity may flow through without impediment. The various lines extending from the Battery to Spuyten Duyvil all finally converge at the Central Office; one end of each of the 56 coming in from the North and the other end of each from the South. They leave the tall poles in front of the headquarters, and are conducted carefully over its roof and down to heavy spars, whence they pass directly into the office. Here they are continued systematically to the batteries and instruments, but are so colored as to designate the particular office which each has to serve.

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* Metallurgists, especially, will appreciate the suggestive import of the truths presented under the first and third heads; here enunciated, as we think, for the first time. It is to be noted that all the above effects belong to the *maximum* kind, and, of course, reach their development only under the most favorable conditions in each case respectively.

Insiruments.

The instruments and appliances at the Central Office consist of batteries, switch-board, register or receiver, indicator, transmitters, clock, repeater and testing apparatus. The apparatus outside of the Central Office consist of automatic street signal boxes and mechanical gong strikers. All of these instruments are of the most perfect and elaborate construction, and most of them especially invented, designed and made for the service of the complete system.

Batteries.

These are compactly arranged in series of shelves, so as to be easily accessible. The shelves and stands are very thoroughly insulated, and the peculiar form of the battery keeps it perfectly clean and dry. The zinc element of this battery is so formed as to make a cover to the glass jar, and thus prevent evaporation and the introduction of foreign matter in the interior. All batteries give off currents of electricity of various power, according to the amount of chemical substances destroyed—but they are almost universally constructed so that the plates are plunged into a reservoir of acids or chemicals, which act directly upon the plates, unless labor is expended upon them to keep them protected, or upon the other parts of the battery to keep them clean. There is thus a large amount of destruction of material independent of that due to the evolution of electric force. This destruction is called local action. If this abnormal action can be guarded against two beneficial results ensue—economy of material is secured and constancy of electric force and incidental labor is saved. The constancy of force is a very great consideration in a system where, for the first time, is introduced apparatus for the exact and instant measurement of electric force on every line. The experiments to secure this evenness of power and small consumption of material were carried on for more than a year upon the old lines of the New York Fire Telegraph. For more than twelve months a steady current was supplied by means of these batteries—the only labor required being the occasional supply of crystals. Without describing any other features of the battery, it may be simply said that the principle of the long endurance is found in the arrangement by which a steady but minute supply of active chemical is supplied continually; the supply is regulated to the requirements of the line. Only one-tenth of the expenditure of chemicals and labor are required. As it has been considered the best policy to keep the entire system of lines in a state of continuous and simple intercommunication, and as the expense of sustaining such batteries has been so much reduced, a very large number of cups are maintained, which, if extended, would occupy nine hundred feet in length. Beside these batteries others are provided for special purposes. The wires leading from these batteries are carried into the operating room symmetrically, and with a view to their easy and instant identification.

The Switch-Board.

In all cases where many wires carry electrical currents into offices it becomes necessary at times to change the direction of these currents—to transfer them from one wire to another for various purposes—just as an engine and train of cars are diverted from one track to another. The same name is given to these devices, viz: "switch." When many wires are introduced, each requiring its switches for its various purposes, the assemblage is called a "switch-board." That of the New York Fire Alarm is superbly mounted, is nine feet in length, and has upon it upwards of five hundred switches, each performing its own special duty—but also arranged and grouped together so that very many may be moved by one common impulse, as when it is required to convert certain series on the entire number of lines from receiving to transmitting lines. To prevent oxidation the rubbing surfaces are heavily coated with platina. This combination gives the operator in charge the power of instantly applying to each and every line the changes which will be described. Unlike ordinary telegraph lines, the wires of the Fire Alarm do not pursue their course from the Central office to the most distant station, and then dipping into the earth, consign the electric current to it, to be carried through it to the point of starting—thus making the earth the conductor for the return current—but the currents of the Fire Alarm return by wires. They leave and return to the office in what are called "metallic circuits." It is far better where lines are comparatively short to make the entire conductor metallic. If no connection is had with the earth in any part of the line, slight defects of insulation and contact with houses or poles do not seriously affect the working of the circuits. Exigencies occur when it becomes desirable to divide the lines for tests or repairs. Through the switch-board the operator turns his north end into the earth, with or without a battery; also the south end, with or without a battery; or, in case of the apparent weakening of the battery, as made evident by a little tell-tale instrument yet to be described, he has the power of testing the exact force of his battery either off or on the line. He can also instantly exchange his enfeebled battery for his choice of several fresh ones, and he may change the course of the current of either of these fresh batteries, or, finally, he may place any one or all the lines in communication with the "repeater," thus changing them from receiving lines to transmitting.

Usually it is desirable to send out alarms, not only to all the alarm stations—that is, the engine houses, &c.—but also back again to the signal boxes throughout the whole island. The change, therefore, of all the lines from "signal" (that is, those that give the first alarm TO the Central Office) to "alarm" (that is, those that receive the alarm sent out FROM that office) can be effected by almost a single movement on the switch-board. In order to give simplicity and order to the arrangement of this instrument, each and every line has its series of switches for these various changes arranged in rows. Every switch has designated upon it, in raised letters, the office it performs. Each and every line is alike, and each is numbered. They are also divided in sections of eight lines, so that it becomes quite easy to refer to any line without loss of time. Immediately in connection with the switch-board is a series of—

Galvanometers.

These are instruments which measure the force of current on the line by deflection of a needle. A few degrees indicate a weak current, and many degrees a strong one. It is thus a valuable register of the state of the line—for the normal condition of the line being twenty degrees, ten degrees would indicate that the battery was becoming weak, and forty degrees would indicate that the battery was becoming stronger, which could not easily occur, or else that resistance at the line was lessened, or that the current had found some short road easier for it to travel than through all the length of the line with its numerous magnets. This measurement by degrees would be only a partial indication of the state of things. Hence to every one of these galvanometers is added that which makes the test an exact one. The "resistance" of a circuit or line is that obstacle it presents to the free passage of the electric current. Through a short circuit of large wire a large volume of electricity will pass and exercise powerful force upon magnetic instruments. Through a long circuit of fine wire the reverse is the case. Suppose a line five miles in length has included in it ten magnets, each of them being furnished with wire a mile long—or, as it is called, a mile "resistance"—the whole resistance would then be fifteen miles; but, if the current, instead of passing through all this length, proceed only two miles, and through only five magnets, and then gets back again, it is evident that it meets with only seven miles of resistance instead of fifteen. Hence we can often locate a trouble if we know the exact resistance of a line and compare it with the normal resistance of that line when all is in proper working order.

The process of ascertaining the exact resistance is as follows:— The needle of the galvanometer is made to deflect by the influence of a long coil of wire placed under it. When the current passes through the coil in one direction the needle deflects to the left; but we may add another coil of exactly equal power, so wound and placed that the needle may be pulled (by equal current) just as strongly to the right. Now, if we give a chance to the current from the same battery to go around these two coils at the same time, just as much will flow through each, and the needle being pulled in two ways with equal force, it will stand at zero. Again, if we add resistance to the wire connected with one coil and none to the other, then a greater part of the current will take the short road, and the coil without resistance will pull the needle the strongest. Hence, if we have a known adjustable resistance connected with the second coil, and the first coil is connected with the line, when we have so altered and increased or decreased the known resistance that it equals the line resistance, and the needle stands at zero, the line resistance, of course, equals the measured resistance exactly.

The very resistance of lines thus tested daily, and recorded in a book, will be a complete history of the state of such lines. The instrument which contains the coils of measured resistance wires, by a combination of which any desired length of resistance is thrown in is called a "rheostat." In the Central Office it is arranged unlike any other such instrument, so that the changes may be made almost instantly, and at the same time can be read off in decimal numbers, indicating miles and tenths of miles.

The Register or Receiving Instrument.

This is the apparatus by which are recorded all the alarms that are sent into the Central office, and all the tests of the day and night. The currents from the lines do not immediately proceed to this machine, but through the usual intervention of the relay magnet, of which fifty-six, in very compact form, are arranged upon the register-table. These relays act upon the register, and also, at the same time, upon an electric annunciator, by which the number of the line is indicated. When a signal is communicated to the Central Office from a street box, the first operation the box performs is to disturb and break up the current that steadily flows through the line at all times, and holds the relay magnet steadily charged. This break discharges the little magnet, its lever falls back, and, in so doing, instantly performs four operations. First, it throws down into view the number of the line called into action; it causes a bell to be rung; it starts the register wheel-work into revolution, and it prints a dot in ink upon a broad band of paper, which is rolled through the machine. If this single action was all that took place a single dot would be printed on the paper, which would run out about three inches and then the revolution would instantly cease, but it can be arranged that the paper shall run only two inches, more or less, before it stops. As long, however, as the line continues to be active by sending off signals, just so long will the paper keep running—always stopping, however, two inches, more or less, as adjusted, after the very last impulse from the line. This paper roll is about ten inches wide. Fifty-six pens, actuated by fifty-six magnets, are arranged beneath it, so that each and every one may be brought to bear upon the paper. Each one is connected with a separate line. The pens are numbered to correspond with the lines, from one to fifty-six.

Suppose that the signal 256 is to be sent in. The street box which sends this particular signal is one of those connected with line No. 21. The operation, then, of the bringing that box into action is, first, to start the paper roll into movement, and to throw into sight No. 21, to call into action the twenty-first pen, which, with great exactness, prints the signal 256 in ink upon the paper five times, and then the paper stops itself two inches after the last printed dot. Thus every signal sent over any of the lines is printed upon this same roll of paper either day or night. But the paper also records clearly another signal, which is automatic. A very fine regulating clock is suspended on the wall of the office. Precisely at each hour on the beat of the first second a type corresponding with the hour of the day strikes upon the paper roll and prints it. In the daytime the hour figures are different from those indicating the night hours. At the same moment a small bell is started, ringing continuously, notifying the operator in charge that the hour has come, and that he must proceed to test all his lines, and print the record that he has done so upon the paper. His duty is then to open for an instant each and every key on each and every line. These keys being arranged in groups of eight, may be struck in groups or singly. The single touch of all these keys makes upon the register paper fifty-six dots corresponding with the fifty-six lines; and if no alarm of fire should come in to be recorded on the same paper, on any one of the lines, then, at the commencement of the next hour, it would be printed in the same way as before on the paper, and another series of tests would be made. Thus, at the end of a day's operations the paper would show that, between the striking of every hour, day and night, every line had been tested and its good condition recorded upon paper; or, if its pen failed to make a record, explanation of the cause would be sought for and the difficulty obviated. Whatever fire might occur between any hours, would be also recorded in its appropriate place, and the paper thus becomes a record of the locality of every fire, the time that it occurred, and also the sound condition of all the lines. The clock which serves to actuate the printing of the hours upon the paper, can also be made easily, by the agency of certain switches, to strike the precise commencement of any hour upon each or all of the six hundred stations embraced in the entire system. In direct connection with this register and its supplementary apparatus through the medium of the wires, are the

Street Boxes.

These boxes form, of course, a very important part of the apparatus of the system. They are fastened to the poles or engine houses, and consist of an outer casing or house of iron, with the seal of the Metropolitan Fire Department on each, and a label covered with glass indicating to the public where the key, which opens the box, may be found. Every policeman is also furnished with a key, and every fireman, and the insurance patrol. When a fire occurs in the neighborhood of a box any one who first obtains the key opens the outer box. Within it he perceives a second iron box, and fastened to it a handle to be pulled down. Printed directions are also visible to guide in doing this simple thing in the right way, and also showing how it may be known that pulling the handle has been effective. The moment the opener of a box hears a response he knows that his work is done. The officers in the department, who have keys for the inner box, to which the handle is fastened, discover, upon opening them, a third box, round, and tightly closed up from the air; on the outside of this third box is to be seen simply a brass arm extending out to the right. This brass arm is fastened to the apparatus within the round box. The office of the pulling down handle on the second box is, to engage with and pull down this brass arm.

The action upon the arm winds up the machine within, which begins running down as soon as the brass arm is left free to move by the disengagement of the pulling down handle.

Opening the round box (previously, however, removing the brass arm), within is found a very excellently finished piece of clock work, driven by a spring, which is so attached outside of the frame that if it breaks, another can be supplied without pulling the frame to pieces. The arm winds up the machine like a watch, but only a short distance. It begins to run down, and in doing so, as the movement is controlled by a very perfect regulator, one of the wheels of the trains carries a "circuit wheel," with teeth cut on it corresponding with the particular number-signal which the iron box represents. The office of the regulated clock work is to carry this circuit-wheel very steadily and slowly around from one to five times, as it is set. Each time it revolves its teeth strike upon springs, and the circuit is made to open and close correspondingly. Two teeth—a space—then three teeth and another space, and then four teeth, and a long space would cause the circuit to be opened and closed, so as to ring out the number 234. As every box has a circuit-wheel with a different number, the starting of the machine of any box communicates its special number with certainty, five times repeated, to the Central Office, and it is printed on the paper of the register five times. In addition to this machine the second box contains a magnetic bell which rings in accordance with the signal sent, and thus becomes an indicator that the message is going correctly to the Central Office; it also receives the return signal from the Central Office, and any and every desired signal which is sent out from that place. There is also a telegraph key by which messages, if necessary, may be sent; also a lightning arrester; also a simple arrangement which, turned either right or left, divides the line into two parts, so that if any accident should occur to interrupt the continuity of the circuit, preventing the current from going to or returning from the Central Office the uninjured part of the line may be almost immediately utilized, and instead of having ten boxes thrown out of use, the loss may be reduced to a single one. Thus a fire may burn down a pole or break a wire, but in a very few minutes the accident is known, and the line which has been broken is made into two short ones, until the time when it becomes practicable to reunite the broken ends.

The other principal receiving instruments in the office consist of two extra and ordinary registers by which the communications with the boxes which may be necessary for keeping the lines in perfect repair and good order are carried on, so as not to allow the main register to be cumbered by them. The apparatus for *sending out* the fire signals, received from and through the machines just described, consist of the repeater, the supplementary repeater and the mechanical gong strikers.

(To be Continued.)

Black Platina upon Zinc.—By M. Neumann. The author has instituted a series of researches to find out the best and most suitable material to produce upon zinc—or rather upon statuary or ornamental objects made of that material—a pleasing blackish coating, without the necessity of impairing the effect of the natural color of the metal, as would be the case when an oil paint or varnish is used. The best results were obtained by the author when nitrate of protoxide of manganese was used; this salt, on being heated, is decomposed, yielding black peroxide of manganese, and the degree of heat required is not so high as to affect the zinc. To 1 litre of pure water, 54 grammes of the nitrate alluded to, and containing six equivalents of water of crystallization, is, according to the author, the best solution for this purpose; and the specific gravity of this solution at 14° R., is stated by the author to be 1·125.—*Dingler's Polytechnic Journal.*

AVOGADRO'S LAW DEDUCED FROM THE FUNDAMENTAL PRINCIPLE OF THE MECHANICAL THEORY OF GASES.

By Alex. Neumann. Translated by Albert R. Leeds.*

Avogadro's Law, that equal volumes of different gases at the same pressure and temperature contain an equal number of molecules, is certainly prized by the majority of scientific chemists as the surest foundation of those molecular and atomic weights, which permit the chemical constitution and reactions to be expressed in the simplest manner. It might, therefore, not be without value to prove that we are necessarily led from an altogether different point of departure, and upon an altogether different road, to the same law.

The pressure of gases is the sum of all the impacts, which the molecules in consequence of their progressive motion exert upon bounding surfaces. The pressure upon the surface unit will therefore depend—1. Upon the mass of the individual molecule. 2. Upon its velocity. 3. Upon the gas volume. 4. Upon the number of molecules present. In one case let the mass of the molecule be m and its velocity c, in another its mass M and its velocity C. Since the magnitude of the impact stands in direct relation to the mass and velocity, it is proportional to the magnitude of both or the momentum, *i. e.*, $\frac{m\,c}{\mathrm{M\,C}}$. Again, the number of impacts made by a molecule in equal times is proportional to its velocity, *i. e.*, $=\frac{c}{\mathrm{C}}$. Therefore, the pressures relate themselves in regard to masses and velocities as—

$$\frac{p}{\mathrm{P}}=\frac{m\,c^2}{\mathrm{M\,C}^2}=\frac{\frac{m\,c^2}{2}}{\frac{\mathrm{M\,C}^2}{2}}, \qquad \text{(1.)}$$

If we imagine n molecules at equal distances and in a state of rest in a space of the cubic capacity v, then there are in contact with the cubic unit $n_1=\frac{n}{v}$ molecules; with a line equal to the unit of length $l=\sqrt{\frac{n}{v}}$, and with the square unit $f=\left(\sqrt[3]{\frac{n}{v}}\right)^2$ molecules. If now, the number of molecules remaining the same, the volume

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* Ber. der Deutsch. Chem, Gesellsch. zu Berlin, page 690, 1869.

v is changed to volume V, then there will be in contact with the cubic unit, $n_2 = \frac{n}{\mathrm{V}}$ molecules, with the unit of length $\mathrm{L} = \sqrt[3]{\frac{n}{\mathrm{V}}}$, and with the square unit $\mathrm{F} = \left(\sqrt[3]{\frac{n}{\mathrm{V}}}\right)^2$. Now, in a state of motion, the pressure must be proportional to the number of molecules impinging upon the square unit in equal times, *i. e.* proportional both to the number of molecules in contact with it at a certain instant, and also to the number of molecules along the unit of length, because the surface unit will be impinged upon so many times more frequently as the distance of the molecules one from another is less or—

$$\frac{p}{\mathrm{P}} = \frac{f\,l}{\mathrm{F}\,\mathrm{L}} = \frac{\left(\sqrt[3]{\frac{n}{v}}\right)^2 \sqrt[3]{\frac{n}{v}}}{\left(\sqrt[3]{\frac{n}{\mathrm{V}}}\right)^2 \sqrt[3]{\frac{n}{\mathrm{V}}}} = \frac{\frac{n}{v}}{\frac{n}{\mathrm{V}}} = \frac{\mathrm{V}}{v}, \quad . \quad . \quad (2.)$$

From equation (2) follows also $\frac{p}{\mathrm{P}} = \frac{n}{v}\,\frac{\mathrm{V}}{n} = \frac{n_1}{n_2}$. Since this ratio $\frac{n_1}{n_2}$ of the molecules contained in the volume unit is equal to the ratio $\frac{n}{\mathrm{N}}$ of the number of molecules contained in equal volumes $v = \mathrm{V}$, so for equal volumes is—

$$\frac{p}{\mathrm{P}} = \frac{n}{\mathrm{N}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

If the volumes as well as the number of molecules are different, we shall obtain from equations (2) and (3)—

$$\frac{p}{\mathrm{P}} = \frac{n}{\mathrm{N}}\,\frac{\mathrm{V}}{v}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4.)$$

Moreover, from equations (4) and (1) we shall have—

$$\frac{p}{\mathrm{P}} = \frac{n\,\mathrm{V}\,\frac{m\,c^2}{2}}{\mathrm{N}\,v\,\frac{\mathrm{M}\,\mathrm{C}^2}{2}}, \quad . \quad . \quad . \quad . \quad (5.)$$

According to the experimental law of Mariotte and Gay Lussac, we have for the same gas the volume remaining constant—

$$\frac{p_1}{\mathrm{P}_2} = \frac{n_1}{n_2}\,\frac{273 + t_1}{273 + t_2} = \frac{n_1\,\mathrm{T}_1}{n_2\,\mathrm{T}_2}, \quad . \quad . \quad . \quad . \quad (6.)$$

in which the ratio of the numbers n_1 and n_2 of the molecules contained in equal volumes, expresses at the same time the density;

T_1 and T_2 indicate the so-called absolute temperatures—numbered on from — 273° C.

If we denote, however, for equal volumes of the same gas the velocities of the molecules, corresponding to the absolute temperatures T_1 and T_2, equation 5 becomes—

$$\frac{p_1}{p_2} = \frac{n_1 \frac{m\,c_1^2}{2}}{n_2 \frac{m\,c_2^2}{2}}, \qquad \ldots \ldots \qquad (7.)$$

From equations (6) and (7) we have—

$$\frac{\frac{m\,c_1^2}{2}}{\frac{m\,c_2^2}{2}} = \frac{T^1}{T_2}, \qquad \ldots \ldots \qquad (8.)$$

When different gases, which do not react together of the same temperature are mingled, at a temperature, for example, T_2, this temperature remains unaltered, being independent of the relative quantities of the mixed gases and of their volumes. Therefore, at the same temperature, the *vis viva* of the moving molecules must be equally great in different gases, *i. e.*—

$$\frac{m\,c_2^2}{2} = \frac{M\,C_2^2}{2}, \qquad \ldots \ldots \qquad (9.)$$

From equations (8) and (9) we have—

$$\frac{\frac{m\,c_1^2}{2}}{\frac{M\,C_2^2}{2}} = \frac{T_1}{T_2}, \qquad \ldots \ldots \qquad (10.)$$

If, for the ratio of the *vis vivas* in equation (5) we substitute the ratio of the absolute temperatures according to equation (10) we shall have—

$$\frac{p}{P} = \frac{n\,V\,T_1}{N\,v\,T_2}, \qquad \ldots \ldots \qquad (11.)$$

Finally, we make in equation (11)—

$$p = P,\ T_1 = T_2,\ v = V$$

we shall have— $n = N$, ... (12.)

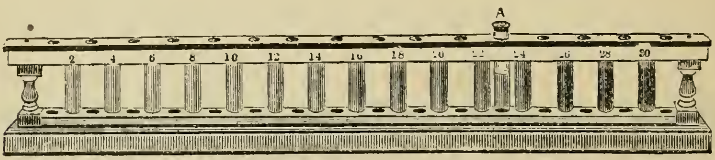
i. e., at the same pressure and at the same temperature, equal volumes of different gases contain the same number of molecules.

THE DETERMINATION OF COMBINED CARBON IN IRON AND STEEL BY THE COLORIMETRIC PROCESS.

By J. Blodget Britton, of the Iron-Masters' Laboratory.

Long ago Professor Eggertz, of Fahlun, Sweden, called the attention of metallurgical chemists to the fact that when pure metallic iron is dissolved in nitric acid, of common strength, the solution, if not too concentrated, is colorless or nearly so, but when steel or iron containing carbon in combination is substituted for the pure metal the solution is colored, and the shade varies exactly in proportion to the amount of carbon present; and, based upon this fact, he suggested a method whereby carbon determinations, sufficiently accurate for many commercial purposes, could be made with facility.

Several modifications of this method have been proposed. One of them, affording exceedingly accurate results, has been in use at the Iron Masters' Laboratory for some time. Instead of a single tube containing a standard solution for comparison, as suggested by Eggertz, a number of tubes having their solutions differently standardized, one from the other, are employed. These are arranged securely in a walnut-wood frame with spaces between for placing the tube containing the solution to be tested, and forming together a convenient portable instrument called a colorimeter—an exact representation of such an instrument is here annexed. The position of the tube containing the solution to be tested is shown at A.



The tubes are $\frac{5}{8}$ of an inch in diameter and $3\frac{1}{2}$ inches in length, filled with water and alcohol colored with roasted coffee and hermetically sealed. The solution in the tube to the left has its color to correspond exactly with one produced by 1 grm. of iron containing ·02 per cent. of combined carbon dissolved in 15 C. C. of nitric acid. The solution in the tube next to it has its color to correspond with one produced by the same quantity of iron but containing ·04 per cent. of combined carbon, and so with each of the other tubes, increasing ·02 per cent. of carbon in regular succession to the right, the last reaching ·30 per cent. as indicated by the figures on the upper rail of the instrument.

On the back of the instrument, and for the purpose of partially screening the light and allowing the different shades of color to be distinctly discerned, there is tightly stretched between the rails some fine white parchment paper. This screen is not shown by the cut but it serves a very important purpose.

The process is conducted as follows: 1 grm. of the finely divided metal is put into a tube of about one inch and a-half in diameter and ten inches long, and digested for fifteen or twenty minutes in 10 C. C. of nitric acid of a little more than 1·20 s. g. free from chlorine. The solution is then cautiously poured into a beaker, and a small portion of metal which remains undissolved and adheres to the bottom of the tube, is treated with 5 C. C. of fresh acid and exposed to a gentle heat till completely dissolved and added to the other. The contents of the beaker, when sufficiently cool, are filtered through two thicknesses of German paper (not previously moistened and of a diameter not exceeding 4½ inches) into a tube about 5 inches long and of precisely the same diameter as those in the instrument.

After the filtered solution has remained for some minutes at the temperature of the atmosphere, and its color become fixed, the tube is placed in the instrument and the carbon determined by a comparison of shades;—the determination may be made readily as close as ·01 per cent.

Heat should not be applied in the first instance to facilitate the solution of the metal, because a high temperature is apt to cause a slight loss of color. Two thicknesses of paper are taken because one alone is liable to break; and the paper should be used dry, for if previously wetted the water will weaken the color of the solution, and it ought to be cut to a size not exceeding 4½ inches to prevent undue absorption.

If the metal to be examined contains more than 30 per cent. of carbon, ·5 grm., or less of it, may be taken, or the solution may be diluted with an equal volume or more of water and the proper allowance made; or an instrument of higher range may be used. On the other hand, if the metal contains a very small per cent. of carbon 2 grms of it may be taken.

For preparing the standard solutions (the normal ones begin to lose color after some hours,) caramel dissolved in equal parts of water and alcohol, as suggested by Eggertz, answers well; but with roasted coffee as the coloring matter I have succeeded in obtaining the true shades. I must say, however, that this latter solution has not been in use sufficiently long to allow me to positively assert that its color will not change after some length of time. As a rule the instruments are kept in the dark except when in actual use, and no perceptible change has yet taken place.

ILLUMINATED FOUNTAINS.

By Professor Henry Morton, Ph. D.

In a previous number of this *Journal*, Vol. LV., page 206, I gave a description of a simple and effective arrangement for illustrating the total reflection of light in the interior of a liquid vein. In another form a less theoretically interesting, but more beautiful, illuminated fountain may be arranged as follows, the description being taken from one which I used in one of my lectures at the Franklin Institute, during the Winter before last.

On a light table about 3 feet 6 inches in height, is placed a shallow basin, or pan of tin, six feet in diameter and about $2\frac{1}{2}$ inches deep, supported by a skeleton framing of wood. Around the edge of this basin is placed a ring of $\frac{3}{4}$ inch lead pipe provided with 50 vertical jets, each of $\frac{1}{32}$ inch aperture turned slightly inward. Towards the centre is a ring of similar pipe 18 inches in diameter, also provided with 50 similar vertical jets inclined slightly outwards. Both pipes are connected with the water supply but controlled by separate stop cocks.

When operating together they form a beautiful pyramidal sheaf of spray (in the case just mentioned) 15 feet high and 6 feet in diameter at the base. The jets are each attached by a short piece of $\frac{1}{8}$ inch lead tube which allows of their ready adjustment in direction.

So much for the fountain, we next come to the arrangements for illumination.

On the lower part of the table-frame which supports the basin is arranged an ordinary magic lantern with its condensers in its roof, protected by an inclined plate of glass, directing the ascending stream of heated gases to a crooked chimney of $1\frac{1}{2}$ inch tin pipe. Immediately above these condensers is an opening through the basin with a high margin to it, on top of which fits a cap carrying a plano convex lens of about 7 inch focus, placed with its plano side uppermost and fitted water-tight in a cell with a deep rim. This cell being then filled with water, we get rid of the otherwise serious effect from a misplaced drop of spray on the glass, which now only causes an instant's disturbance to the action of the lens, but otherwise would greatly modify its effect if lying as a bead upon it.

This lens is so adjusted with regard to focal length and position, as to make on the ceiling, about 16 feet from the tank, a circle of light 3 feet in diameter. To the ceiling, at this place, is attached a plain mirror which then reflects the incident light at the same angle, so making a truncated cone 3 feet at top and 6 feet at base, which just takes in the entire sheaf of jets.

This arrangement alone gives a very beautiful effect, but further, to increase the illumination, I had a hole cut through the ceiling from the floor above just outside of the mirror, and through this directed a cone of light from a lantern with its nose-end downwards.

By using parti-colored figures of gelatine, similtaneously in the two lanterns, the effect was beautiful beyond description, a veritable fountain of various scintillating jewels was produced. By adjusting and turning on the light first, and afterwards the water, this last seemed to be the veritable source of the illumination. The light without the water jets was scarcely appreciable to any one not close to the tank, while the moment the fountain was turned on the whole room was lit up. The most pleasing effect of all was obtained by making glass circles with six segments of different colors and rotating these slowly in the upper lantern; the changing prismatic tints of the various sprays being something that, literally, "must be seen to be appreciated."

Franklin Institute.

Proceedings of the Stated Monthly Meeting, March 16th, 1870.

The meeting was called to order, with Mr. Coleman Sellers, the President, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting, held March 9th inst., on the written request of Messrs. Wm. Sellers, Henry Cartwright, Washington Jones, Henry Morton, Coleman Sellers, J. Vaughan Merrick, John Birkbeck, Joseph M. Wilson, Jacob Naylor, W. Barnet Le Van, Theo. Bergner, R. E. Griffith, Charles S. Close, and Enoch Lewis, the Board constituted them the section of Mechanical Engineers of the Institute.

Donations were received from the Chemical Society, the Royal Astronomical Society, and the Society of Arts, London; l'Academie des Sciences, la Société d'Encouragement pour l'Industrie Nationale, Paris, France, der K. K. Geologischen, Reichsanstalt, Vienna, Austria, Commodore B. F. Sands, Superintendent of the U. S. Naval Observatory, Washington, D. C., the Peabody Institute, Baltimore, Maryland, the Water Commissioners, Detroit, Michigan, Lieut. H. E. Hayes, City of New York, and the College of Pharmacy, Philadelphia.

A paper on Rotary Printing Machines, by Mr. Hector Orr, was then read, and the thanks of the Institute were presented to Mr. Orr by the President, after which the report of the Resident Secretary, on Novelties in Science and the Mechanic Arts was read, and then the meeting, on motion, adjourned.

HENRY MORTON, *Secretary.*

Coating of Glass, Porcelain or Earthenware with a thin film of Lustrous Metallic Platinum.—By Prof. Boettger.—Dry chloride of platinum, freed from excess of acid, is mixed, in a small porcelain mortar, with essential oil of rosmarine (oleum anthos) until the original brown-red color of the salt has entirely disappeared and has been converted into a black, pitch-like looking mass. In order to effect this result, it will be necessary to renew the essential oil at least three times. When the pitch-like mass has been obtained the oil is entirely removed, and the pasty mass is weighed, and afterwards mixed with at least five times its weight of lavender oil, and makes therewith an homogeneous fluid; this, after having been quietly standing for half-an-hour is applied with a hair brush on the glass or porcelain objects to which it is desired to give a coating of lustrous platinum; and after the very thinly and evenly laid on film is dry, the objects are either placed in a red-hot muffle or heated in the flame of a glass-blower's lamp, care being taken not to exceed a red heat.—*Dingler's Polytechnic Journal.*

JOURNAL

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Vol. LIX.] JUNE, 1870. [No. 6.

EDITORIAL.

ITEMS AND NOVELTIES

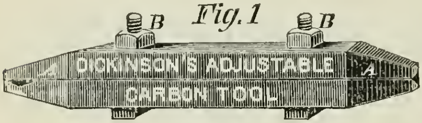
Cutting-Tools of "Black Diamond."—At the last meeting of the Franklin Institute, mention was made of the remarkable work which had been done with these tools at the establishment of William Sellers & Co., and at that of J. E. Mitchell.

At Mr. Sellers' works, one of these fragments had been in use, during several months, for turning off the large grindstones, and had performed this arduous service some fifteen or twenty times without sensible deterioration or loss of substance to itself. It was, moreover, stated that with this material a cut could be made on such a substance as that of the grindstone exactly as though this latter were soft iron or wood. Mr. Coleman Sellers exhibited a drill for glass prepared with the same material, which he had used with great success. Mr. Mitchell said that he had found the carbon cutters invaluable in cutting out small grindstones, which operation was effected by them with wonderful ease and rapidity.

This black diamond or opaque crystalline carbon is identical in substance with the transparent jem, but excells it in hardness in a marked degree. It is found in the long-known diamond localities, as a part of the matrix or surrounding rock.

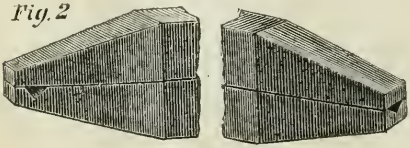
The advantages of these carbon points or cutters, over the natural crystallized carbon or steel, are numerous, the most important of which being that as they are more durable and do not require sharpening, by their being artificially formed into wedge, angular, or other shapes, fewer of them are required; also, they can be firmly and solidly adjusted in dovetailed seats or grooves in a holder or tool, with the greatest facility.

Fig. 1



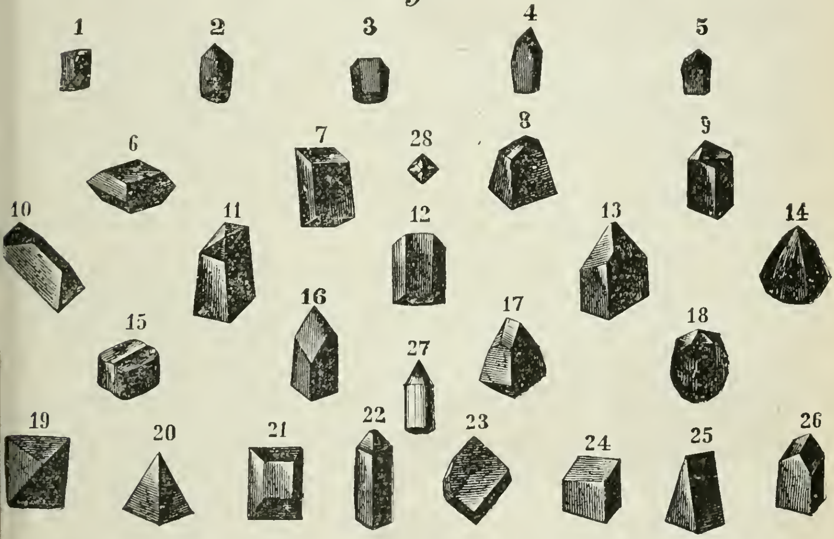
The adjustable tool, Fig. 1, answers admirably for this purpose. Fig. 2 shows, on larger scale, the cavities cut to admit the carbon points which are secured therein by drawing the longitudinal jaws, A A, together by screws, B B. The advantages of this tool are manifold, in making one carbon point answer numerous purposes, thereby economizing time and expense—a great desideratum to a working mechanic. It is obvious that this would not be practicable with carbon in its natural state, owing to its irregularity of shape and want of cutting-edges, and the limited knowledge possessed by mechanics generally of diamonds and their nature, as well as skill requisite in setting them properly.

Fig. 2



The engraving represents some of the various forms to which these diamonds are ground, and are referred to by number. Their uses may be enumerated as follows: No. 1 is a triangular prism-like cutter for turning or working stone, &c. No. 2 is a flat drill point for drilling stone, glass or metal. No. 3 is a burin for cutting or turning metal. No. 4 is a quadrangular prism for working stone, &c. No. 5 is a hexahedron to be inserted in the edge or face of a circular saw for cutting stone. No. 6 is a double-sided trapezoid, used in various positions, for marking or turning stone, steel or other substances. No. 7 is a chisel point or cutter for turning metal, &c. No. 8 is a drill-faced parallelogram for pointing combination drills for drilling and reaming stone, metal, &c. No. 9 is a quadrangular prism with a planer cutting point for cutting or planing metal, &c. No. 10 is a truncated prism for working stone, &c. No. 11 is similar to No. 8, and used for the same purpose. No. 12 is a truncated prism used for facing or edging ring or cylinder drills and circular saws for cutting stone, metal, &c. No. 13 is a quadrangular double-faced drill point for drilling stone, &c. No. 14 is a quadrangular pyramid used for reaming stone or metal. No. 15 is similar to No. 5, and is used for the same purpose. No. 16 is a quadrangular cube, with graver edge, for cutting metal, &c. No. 17 is a flat octahedron for drilling stone, glass, &c. No. 18 is a flat ovoid, with double drill point, for drilling or counter-sinking stone, metal, &c. No. 19 is a tetrahedron, used the same as no 18. No. 20 is a pyramidical drill point, used the same as Nos. 18 and 19. No. 21 is a truncated prism, used the same as Nos. 1 and 10. No. 22 is a drill-pointed prism reamer. No. 23 is similar to No. 22, and used the same. No. 24 the same as No. 7, with angular edges, and used for the same purpose. No. 25 is a double inclined plane wedge for cutting stone

Fig. 3.



or metal. No. 26 is a quadrangular wedge for turning stone or metal. No. 27 is an acute conical-turned diamond point, used for engraving, etching steel by bank note engravers, &c. No. 28 is a diamond in its natural crystallized state, as found in the mines. Crystallized carbon, of which the above points are made, is of a black or gray color, opaque and irregular in shape, and devoid of angles. The above illustrated points or cutters range in size from one-sixteenth of a karat to ten karats each (a karat is equal to four grains). Their perfectness of finish depends upon the purpose and materials to which they are to be applied. For metal they require to be sharper than for stone. The shapes as above given are only approximated in practice, as the granular character of the material renders a fine finish as impossible as the grinding action of these tools makes it unnecessary. (See advertisement 3d page of cover.)

High Level Bridge at Cleveland.—In an address lately delivered before the Scientific Association of the above place, Mr. J. F. Holloway gave a full and interesting discussion of the important questions involved in the proposal to connect the two sections of the city by a high level bridge.

After describing the inconveniences at present experienced from the great descent and elevation to be overcome in crossing the valley of the Cuyahoga, the railroads to be crossed and the drawbridges to be encountered, Mr. Holloway proceeds as follows:

In order to erect a bridge that shall be high enough to allow the passage under it of vessels of the largest class, it must have its floor at an elevation of one hundred and forty or one hundred and forty-five feet above the level of the river; and in order to obtain this height, and also to cross the river at right angles, the western terminus of the bridge must be at or near the high bank near the intersection of Russia and Franklin streets, which is nearly opposite the grain elevator of Gardner, Burt & Co. This terminus will best accommodate the population of the west side of the city, as by its easy connection with Pearl, Franklin, Fulton, Lorain, Detroit, and other streets that branch out from them, the travel of the west side, as well as that of the country beyond, including the Lake road, Rocky river, Brighton, Brooklyn and the Heights, can easily and naturally centre at this point. The most desirable, and, as I think, the only proper termination of the east end of the bridge would be at the foot of Superior street, on the ground now occupied by the Atwater Building; and I think I shall be able to show, in speaking of the detail of the bridge, how this terminus can be made not only without damage to that property, but in such a manner as largely to increase its value.

Taking these two starting points, we have what will be the longest route for a bridge, but one which, in its construction, will be the best for the present as well as the future interest of the city; and, indeed, the only route on which a bridge without a draw can be built with grades that would be passable. The distance between the abutments of the bridge on this route will be about three thousand feet. The elevation of the surface of the street at the Atwater Building is seventy-five feet above the water level. The street grade, at the corner of Pearl and Franklin streets, is one hundred and twelve feet above the level of the water. The western approach to the bridge should begin at this point, while the bridge proper would begin at or near the top of Franklin street hill. The distance from Pearl street to the centre of the river is about nine hundred feet, and if it be found necessary to have the summit of the bridge at one hundred and forty-five feet above water level, we would then have a rise of thirty-three feet to make in nine hundred, equal to a grade of three and two-thirds feet in one hundred, which is a very moderate grade. The approach to the Cincinnati bridge is five feet in one hundred, and the grade at the east end of the Washington street tunnel of Chicago, six and one-fourth feet in one hundred, and up this grade (which is nearly double the proposed grade of the Cleveland bridge), a team of two horses has hauled over four tons. From the centre of the river to the foot of Superior street is about three thousand feet. The difference of elevation between the eastern end of the approach to the bridge and its summit is seventy feet, but as the elevation would be divided into a distance of three thousand feet, the grade would only be two and one-third feet in one hundred, which is equal to the grade of many streets in the city which most people would suppose are nearly or quite level.

As the height of the piers, and consequently their cost, will bear a large proportion of the cost of the bridge, it becomes a question of considerable importance as to what kind of a bridge will be the cheapest under such circumstances, and at the same time have the requisite amount of stability and strength. Inasmuch as several parties are now devising and preparing plans for a bridge suitable for this location, I shall leave out any reference to that part of the subject, simply adding that there is no difficulty in making it either truss or suspension, or a combination of both.

One of the most important advantages pertaining to this bridge scheme, next to its safeness over its present route, is the great saving of time that would occur from its use, if used simply by foot-passengers and by vehicles; but this saving of time can be largely increased by so constructing the bridge as that there shall be two tracks across it for cars. The cars will be propelled by an endless wire rope making the entire circuit of the bridge, and attached to the cars in such a manner as that when one car is at one end of the bridge the other car shall be at the other end. This wire rope (which will be carried on pulleys stationed at various places on the bridge) will be moved by a steam engine located within one of the abutments of the bridge. At intervals of five or ten minutes, during the day, or oftener, as business demands it, the person having charge of the engine will set it in motion, and the cars will start at the same moment from both ends of the bridge, and pass each other in the middle of the same.

The passage of the cars from one end of the bridge to the other, if run at the low speed of twelve miles per hour, would be made in three minutes; but, allowing for the time lost in starting and stopping, it will be safe to say four minutes. Now, the time it requires to go from the top of Superior street hill to the top of Detroit street hill, either by the street cars or by walking, will average twenty minutes, provided there is no delay at the railroad crossing, or that the drawbridges are not open. When either or both of these happen, the time is prolonged to one-half or three-quarters of an hour. Putting the saving of time in crossing at the low average of fifteen minutes for each crossing of the thousands of people who could be carried over in the cars, and multiplying that time saved by the most modest estimate any one would make of the value of his time, you would find the daily saving a very considerable sum. This multiplied not by one year only, but by the years a properly constructed bridge would last, and you have a fabulous sum. In this no account is made of the rest it will offer and the convenience it will afford one to step from a pleasant waiting-room into a comfortable car, and, without delay, or dust, or heat or cold, be safely and quickly carried the long distance that would be bridged over.

* * * * * * * * *

The total number of persons and teams now crossing the river is daily about 15,210 persons and 4,671 teams.

But returning to the detail of the bridge, I would say that the ends of the bridge should be within a depot or bridge house into which the cars of the bridge should run, and from which the approach to the promenade or passage for foot passengers should begin. The bridge house for the eastern end should be in the open space in the rear of the Atwater buildings; and the entrance to the bridge should be through the building. This could be done by removing all the stores on the level of Superior street, leaving the banks on either side, and by opening up the front of the building by arched ways for the passage of teams and passengers. This could be done without disfiguring the front of the building in the least. The space in the rear could be raised up to the street level, by stone or brick arches and girder beams, so as to make it durable and substantial. This space could be enlarged beyond what would be necessary for the use of the bridge alone, and thus by opening up the rear of the present building into store and office fronts, what is now of little value, these would become the most desirable places for business in the city, as it would be in the centre of the greatest thoroughfare within the city limits.

In the centre of this arena would be the waiting room of the bridge cars, and any person desiring to go over on the cars, would enter here and pay their fare as at the bridge house of the New York ferries, and step into the cars if there, or take a seat until they came in; thus no conductor would be necessary on the cars. If they desired to walk over, they would pass through the room and up a short flight of steps, and find themselves on the premenade.

Inasmuch as the width of the bridge will also be a considerable item of its cost, it is desirable to restrict it in that respect as much as possible without detriment to its usefulness. Hence I would propose that the roadway for teams be on each side of the passage for street cars, and thus by dividing the travel into right and left channels, there would be less confusion and delay. As the roadway and car tracks must be separated by a truss in order to give strength to the floor of a bridge, I would carry this truss up high enough to support a floor across over the cars, and at the same time answer for a railing or balustrade to the same. This space floored over between the trusses, each side of the cars would be the promenade or passage for foot passengers; and as it would be wide and roomy, free from dust, affording one of the most magnificent views of the lake, the harbor and its shipping, and of the valley of the Cuyahoga and its winding river possible for any one ever to obtain.

* * * * * * * * *

There is another important feature connected with this bridge of which I desire to say a few words, although it does not pertain to the crossing from one side of the river to the other, and that is: By using the piers made for the high level bridge, a second bridge may be made under the main bridge, by the use of which persons and teams could go from the east side to the valley of the Cuyahoga or to the flats, as it is called, without crossing the railroad tracks at the foot of west Water street. This railway crossing has been the subject of much thought.

* * * * * * * * *

Now, by coming in on to this lower level bridge, part of the way down south Water street, say about opposite the end of Long street, and on Station street, on the Superior street hillside, this bridge could be made high enough to cross over the cars on the railroad and also to cross over James street high enough not to interfere with travel on it; and then on a descending grade, cross the canal and land on West street: or by opening a street through to Centre street, it would connect at once with the end of Columbus street, and thus open up a direct route from the flats to the top of Superior street hill on an easy grade, and do away with all the dangers and delays of the railroad crossing at south Water street.

The relative difficulties of this and other similar works now finished or in progress are then discussed, and it is shown that the plan proposed is far within the limits not only of engineering feasibility but of accomplished results.

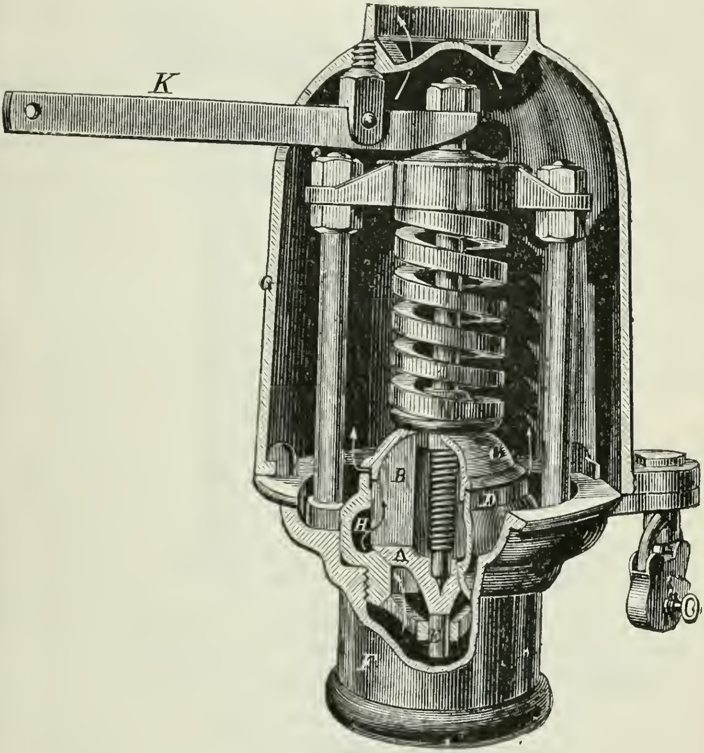
Safety Valve.—Patented by J. D. Lynde.—At the last meeting of the Franklin Institute there was exhibited in operation, and explained by diagrams projected on the screen, the above valve, whose structure and mode of operation is as follows:

Fig. 1 shows it partly in perspective with the "lock up" case, and Fig. 2 is a vertical section of the same valve, as it is constructed for locomotives, I I showing a portion of a dome cap.

A is the valve; B guide wings on top of the valve and connecting the concave disk, C, thereto. D is the rim against which the guide wings bear. E is the guide pin to the valve. F is the guide nut.

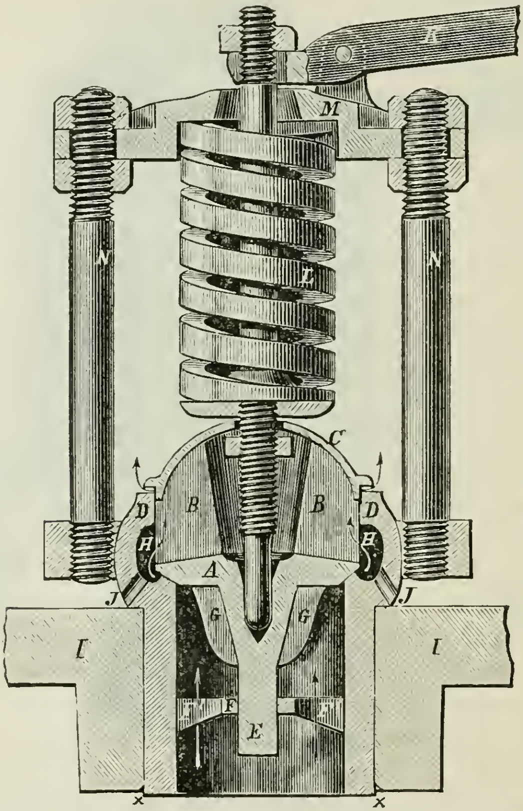
F′ the guide nut braces. G the wings to strengthen the guide pin, E. H is the annular passage for steam around the valve, by which the steam is turned up against the disk, C. K is a lever of any suitable length for trying the valve. The valve is held down by the spiral spring, L, and set as required by the crosshead, M, and bolts and nuts, N N.

Fig. 1.



When the valve, A, begins to rise, the steam will pass through the narrow space (about one sixty-fourth of an inch) between the disk, C, and rim, D. If the pressure then rises, say a couple of pounds higher, the valve opens wider—while the space between the rim and disk has not increased, the sides being vertical—and more steam will pass into the passage, H, than can pass by the disk, C; then the whole force and velocity of the escaping steam will be exerted on the disk carrying it suddenly upward, with the valve, overcoming the increased power of the spring, and permitting the steam to blow off rapidly until the pressure has fallen to near where the valve started to alarm, when it will suddenly close, thus simply blowing off the surplus steam, which will be noticed by engineers to be a *different* action from any other valve.

Fig. 2.



Suez Canal.—Two reports on this great work, which have just appeared, furnish us with several items of interest in addition to what we already have known and seen here recorded on the same subject. In the first place, the report of M. de Lesseps, presented to the shareholders at Paris, states that $1,600,000 will be required this year to complete or improve the works. The total number of vessels passed through the canal from the day of its opening to the the 15th of March, was 209.

Again, in the report of Captain Richards, R. N., and Lieut.-Col. Clark, C. B., sent by the English government to examine the canal, with reference to the future utility of the same to the English marine, we observe that by 52 accurate sections, taken at different points, the canal is found to be essentially completed according to the original, or rather modified, designs of the company, and "is, at the present moment, undeniably a navigable canal for vessels of considerable draft and tonnage."

It appears that the company intend, without delay, to reduce the sharpness of certain curves, and widen the bed at these points to 130 feet on the floor; also, to make the channel at Port Said 30 feet deep. This will require the removal of about 451,000 cubic yards of earth.

It is also intended to mark the banks of the canal by conspicuous beacons at each mile, and to provide posts or bollards for securing ships or heaving them off at every tenth of a mile, and to mark the limits of 16 feet water on each side by buoys placed about 400 yards apart.

According to the same report, no difficulty is to be apprehended in regard to the harbor of Port Said, either with reference to keeping the channel open or in its approach by vessels.

So, also, as to the silting up of the canal by drifting sand, the permanence of the fresh water canal, now ten years old, being conclusive evidence upon this point.

The authors of this report further conclude that the use of this canal will be decidedly advantageous to several classes of war vessels and to the mercantile marine.

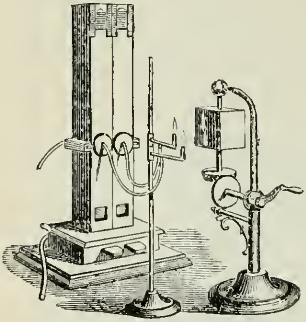
Practical Scientific Instruction.—In the last number of the *Quarterly Journal of Science*, we find an excellent article on the above subject, by George Gore, F.R.S., which contains, among other things, answers to two or three popular fallacies, which are well worthy of repetition, if merely as specimens of epigrammatic force in expression.

Thus it is suggested, if "a *little* knowledge is a dangerous thing," how much more dangerous is still less knowledge?

England spends five times as much on pauperism and crime as on education, whilst Switzerland spends seven times as much on education as on pauperism and crime.

If, as is frequently argued, ignorance has its advantages, how much greater must be those of intelligence?

Sonorous Vibrations Illustrated.—Among the numerous arrangements which have been devised for this purpose, few are more effective than that of Kœnig, of which the accompanying wood-cut illustrates the application. Two gas jets are arranged before a rotating cube of mirrors, and are controlled by valves attached to organ pipes, or other bodies capable of sonorous vibration.



When these vibrate, the flow of gas being varied at each pulsation of the same, the flame leaps up and retreats likewise, and thus its image in the rotating mirror becomes a series of luminous tongues, in place of a smooth-edged band of light, as it appears when the flame is at rest. We are indebted to Mr. E. S. Ritchie, of Boston, whose vital improvements and ingenious modifications in the induction coil and Holtz machine are so well known to our readers, and by whom also this apparatus is manufactured, for the accompanying wood-cut.

Fluids in Crystals.—Vogelsang and Geissler.—A novel application of the spectrum analysis has lately come to our notice, namely to the detection of the chemical nature of the liquids sometimes found in quartz crystals. The above named scientists placed fragments of such crystals in a retort, which they exhausted, and then applied heat, upon which the confined material was liberated, and its vapor collected in a Geissler tube. The only result mentioned in this connection is the detection of carbonic acid.

The Eclipse Observations in 1869.—We quote from a late number of *Nature* a letter by Professor C. A. Young, which contains many items of interest.

"Will you grant me space for a few words on my spectroscopic observations of the American eclipse, and what seem to me the inferences to be drawn from them? I make the request the more freely because I have met from time to time allusions to them in your journal, and remarks, some of which seem to require my notice, if only to express my appreciation of the considerate courtesy with which they have been treated by gentlemen who differ very widely from my conclusions.

"1. Regarding the use of the spectroscope in the observation of 'contacts.'

"I think the language of Mr. Stone and some others in a discussion of the matter at a meeting of the Astronomical Society, reported in your columns in December last, implies a misapprehension. What I have proposed (and executed in the case of the moon) is to use the extinction of the bright C line in the spectrum of the chromosphere as a criterion of contact with the limb of the *photosphere*, not with the upper surface of the chromosphere, which would, of course, as indicated by Mr. Stone, be a perfectly worthless observation.

"The value of the method lies in this, that it furnishes an easily apprehended phenomenon to be watched for, and gives every advantage of preparation to the observer.

"With an instrument of moderate dispersive power, the slit must be normal to the sun's limb, and an accurate knowledge of the expected point of contact is required: with a more powerful instrument the slit can be placed tangential, opened somewhat widely, and thus all difficulty on this score avoided, as I have pointed out in my report. I see by a paper of Mr. Proctor's in the December number of the *Monthly Notices*, that Mr. Huggins suggests the same plan.

"Perhaps I may remark in passing that the idea of using the spectroscope in this manner to observe the contact of the moon with the sun's disk, was conceived before the event, so that the observation was made deliberately and by pre-arrangement—not at all accidentally, as would rather seem to be implied by one of the opening sentences in the article of Mr. Proctor's above referred to. To M. Faye, however, belongs whatever merit there may be in the method, for he proposed essentially the same thing in January, 1869. But I knew nothing of this at the time of the eclipse, nor indeed till long after.

"2. The self-luminosity of the Corona.

"It is not impossible that the so-called corona may be complex. Some portion of its radiance may *perhaps* originate in our own atmosphere, although I do not yet find myself able to accord with the conclusions of Dr. Gould and Mr. Lockyer in this respect, and am strongly disposed to believe that the *whole* phenomenon is purely solar.

"This much appears certain, however, that there exists outside of the chromosphere properly so called (*i. e.*, the envelope of *red hydrogen*), and as distinct from *it*, as it is from the *photosphere*, an immense atmosphere of self-luminous substance, extending to a distance of from 5′ to 8′ from the sun's surface, and probably much further in places—phosphorescent dust or fog in a glowing gas.

"In support of this idea I adduce the photograph of Mr. Whipple, taken at Shelbyville, Ky., with an exposure of 40 s. On this, the *photolytic corona* (if I may use the expression to distinguish it from the *visible corona*, whose points of maximum brilliance were, according to Dr. Gould, entirely different), reaches a height of 6′. Prof. Harkness observed the 1474 line in the spectrum of the corona at a distance of nearly 5′ from the sun's limb, and not near to any prominence. I do not know the precise elevation at which I saw it, but it was not less than 3′ or 4′.

"Indirectly, also, the idea is confirmed by the spectroscopic observation of Prof. Pickering, who used a single prism instrument, with the slit simply directed towards the sun, not attached to a telescope. He saw only three or four lines, the brightest in the green near E. Now, since this line, when observed by throwing an image of the sun on the slit, is very faint as compared with C, D_3 and F, its intensity, as seen by him, can only be accounted for by supposing that the luminous area from which it was derived far exceeded that of the chromosphere and prominences.

"I have noticed also that some of the observers of the Indian eclipse (Rayet and Pogson) speak of the intensity of the green line. Did they observe in the same manner as Prof. Pickering?

"I need hardly add that Prof. Pickering's observation of the non-polarization of the corona concurs with what has been said.

"As to the faint continuous spectrum, I am sure that the reported absence of dark lines was not the result of insufficient observation.

"I could not have failed to see D, E, *b*, 1961, F and G had they existed, for in a spectrum of similar brightness formed by a light from a cloud, not only these but many other lines are visible in my instrument. Now, the absence of some of these might, perhaps, be accounted for on the ingenious hypothesis proposed by Mr. Lockyer, and reported in your number of February 3; but this would not apply to D, E or G.*

"But if we admit the existence of faintly luminous solid or foggy matter near the sun, either meteoric or arising from the cloudy condensation of a non-permanent gas, the whole is at once easy of comprehension.

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* Why not?—(Editor of *Nature*.)

Answer by Prof. Young.—Because these lines are not reversed in the spectrum of the chromosphere.

"3. The Auroral Theory of the Corona.

"The objection pressed by Mr. Lockyer that the bright line 1474 is only occasionally visible, is, I think, unfounded. At any rate I have never failed to see it myself when looked for, and very seldom to make it visible to others when I have wished to exhibit it to them. It is faint, and, like a difficult microscopic object, requires management to bring it out with five prisms; but by placing the slit tangential to the sun's disk, and giving the instrument a slight jar, it is seen to flash out as the limb passes off the slit. It is worth noting, too, that it is often especially plain at portions of the limb where the chromosphere is unusually shallow and faint.

"But while I think it probable that this line coincides with the aurora line reported by Prof. Winlock, at 1550 of Mr. Huggins' scale, I am by no means sure of it. I understand that the assigned position of this line in the spectrum of the aurora rested upon a single observation with a chemical spectroscope, and the probable error of such a determination cannot well be less than ten divisions of Kirchhoff's scale. I have naturally made many attempts to determine its position for myself, but have only seen it on three occasions, and never long enough at a time to complete a measurement. I am only sure that its position lies between 1460 and 1490 of Kirchhoff.

"For this reason, although I do not at all abandon the hypothesis, which appears to have other elements of probability in the general appearance of the corona, in the certainty of intense electrical disturbances in the solar atmosphere as the result of the powerful vertical currents known to exist there, as well as the curious responsiveness of our terrestrial magnets to solar storms; yet I do not feel in a position to urge it strongly, but rather await developments.

"As to the substance which causes this line, I observe that Father Secchi, in a recent communication to the French Academy, is disposed to think it hydrogen; while Mr. Lockyer still believes it to be iron. I am in hopes that experiments now in progress may throw some light on the subject.

"May I suggest, in closing this long communication, that valuable observations might be made at the eclipse of next December, by fitting up telescopes with a ground glass sliding screen, upon which an image of the corona, two or three inches in diameter, should be thrown; the ground glass having the roughened side next the observer, so that he could sketch upon it with a lead pencil the outlines of the image, the glass being made long enough to allow of several such sketches.

"The comparison of a series of such outlines would decide the question of changes in the coronal streamers, as the sketches, being simple tracings, could not but be accurate in their indications of positions. C. A. YOUNG.

"P. S.—I think that the position of the line reported by me as 2602 should have been 2581·5, an error of one revolution of the micrometer screw having been made. At any rate, on two occasions since the eclipse, I have seen a bright line in the latter position, and I have never been able to find one in the former."

Darmouth College, N. H., March 1.

Editorial Correspondence.

AN IMPROVEMENT IN GALVANIC BATTERIES.

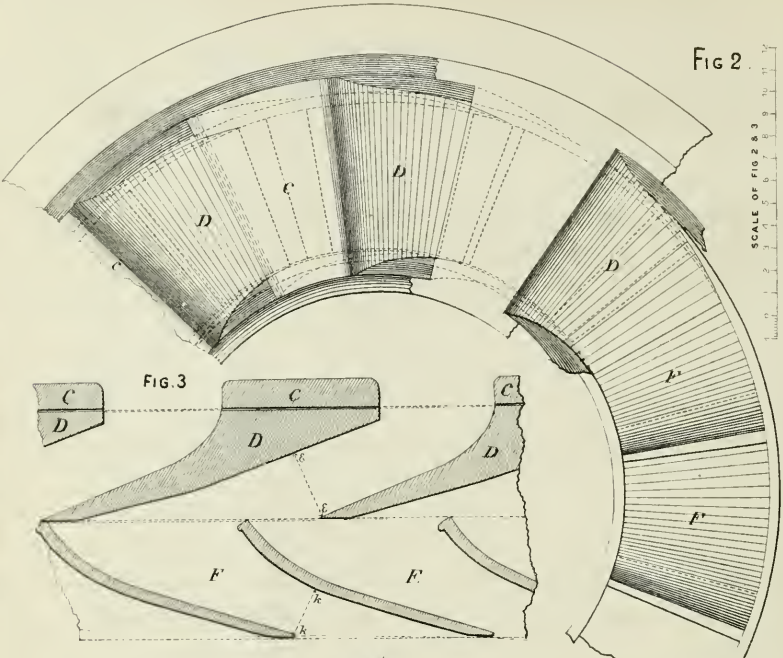
Editor of the Franklin Institute Journal.

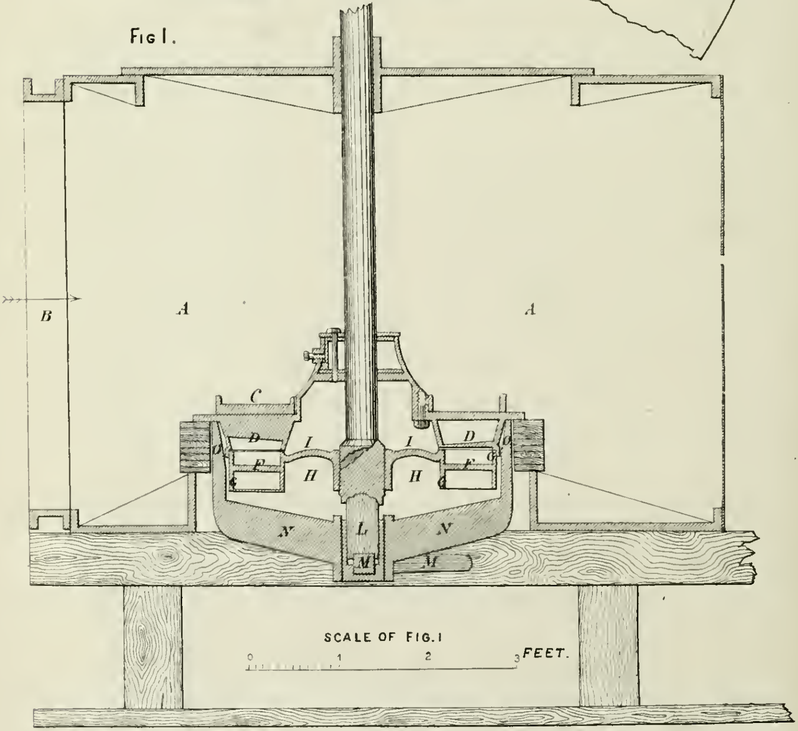
In the spring of 1869, while making use of a small bichromate of potash battery, I discovered that the addition of nitric acid to the mixture of potassic bichromate and sulphuric acid, contained in its porous cups, conferred upon it the virtue of *steadiness*, without involving the evolution of annoying fumes. For over two months, during last summer, I had in almost constant action a combination of twenty-three large Bunsen cells charged with dilute sulphuric acid and the triple mixture mentioned, and "set up" openly upon the floor of my room. Not only did I work about it with perfect comfort, but left choice brass instruments in its immediate neighborhood with impunity. Its energy never fluctuated, but after remaining for some time steady, declined, precisely as if the electro-negative plates were bathed in nitric acid only.

To a cooled mixture of potassic bichromate solution and sulphuric acid (perhaps preferably in atomic proportions) add *nitric* acid. The proportion of nitric acid may be greatly varied, as its office is merely to transfer oxygen. W. Poole Levison.

Cambridge, Mass., 1st May, 1870.

Bodine Turbine Wheel





Baldwin Coolidge del.

Lith. Jas. McGuigan, Phila.

Civil and Mechanical Engineering.

EXPERIMENTS WITH A 35-INCH BODINE (JONVAL) TURBINE MANUFACTURED BY THE BODINE MANUFACTURING COMPANY OF MOUNT MORRIS, NEW YORK, AND WESTFIELD, MASS., MADE AT LOWELL, MASS.

By Hiram F. Mills, C. E.

In these experiments the apparatus used in the experiments upon the Swain Wheel, described and illustrated in the *Journal of the Franklin Institute*, Vol. LIX., No. 3, was used without modification.

The iron curb in which this wheel was placed, which is represented in section in the accompanying plate, was attached to the wooden flume in a manner similar to that previously described, and in such position as to place the wheel and shaft in nearly the same relation to the floor of the pit and the measuring weir.

In the accompanying Plate I., Fig. 1, represents a section of the wheel with guide and gate in place within the curb.

Fig. 2, a plan of a portion of the gate, of the guides and of the wheel.

Fig. 3, a development of a portion of the cylinder containing the outer edges of the buckets of the wheel and cutting the guides.

The curb A consisted of a wrought iron cylinder 8 feet in diameter, and 5 feet high, with cast plates stiffened by flanges at the top and bottom. It was flattened upon one side and stiffened by a casting, to which was joined the circular inlet pipe B, 6 inches long and 54 inches in diameter, inside. This pipe was bolted to the side of the forebay in which was a circular opening with the same diameter.

The gate C, represented open in each of the figures, is of the "register" pattern, being an annular plate, with flanges projecting upwards at its edges, and the space between the flanges perforated with nine openings having radial sides and occupying a little less than one-half of the whole space, leaving the solid part of the ring between the flanges of the same form as the openings. The upper edges around the openings are slightly rounded to lessen the contraction of the stream entering.

The gate is opened and closed by a pinion (not represented) having a vertical shaft passing up through the top of the curb to a hand-wheel, which pinion works into a short rack bolted to the outer flange of the gate-plate.

There are nine guides of cast iron of the form shown at D, so spaced that the gate *c*, Fig. 3, when open just covers the top of each guide, and when closed projects slightly upon each of two adjacent guides.

The mean shortest distance E E, between the guides, is 3·12 inches, and the mean section at this place is 22·2 square inches.

The depth of the guides is 5 inches.

The wheel F F is of cast iron, 35 inches in diameter, and $5\frac{3}{8}$ inches deep. It has twelve buckets of the form represented, which are included between the two cylinders $6\frac{1}{2}$ inches apart, shown in section at G, the inner one of which is connected near the upper edge with the hub H H, by the web or disk I.

The mean smallest section between the buckets at K K is 14·83 square inches, and the total for the 12 buckets 178 square inches. The extreme variation in the areas of these outlets was found to be 3 per cent.

The wheel was cast in one piece, well cleaned and apparently smoothed upon the surface of the buckets with a file, and then covered with a coating of black paint.

The guides were well cleaned free from pimples, and likewise coated with black paint.

The step L is held in the hanger N, and its height regulated by the wedge M. This hanger or bridge-tree consists of four arms crossing at right angles, and attached to the plate surrounding the guides at O by means of screws.

The apparatus used in making these experiments, and the method of conducting them being fully described in Vol. LIX., No. 3 of this *Journal* need no further mention here.

The data and results of the experiments are presented in the following table.

An index was arranged by which the area of the opening at the gate could be determined accurately and by means of this the area was varied from full gate to quarter gate. In the latter case the area of the opening was one-quarter of that with full gate.

The leverage of the scale beam was 10·00.

The circumference of the point of attachment of the scale beam to the friction band was 14·983 feet.

TABLE OF EXPERIMENTS UPON A 35 INCH BODINE WHEEL IN LOWELL, MASS., OCTOBER, 1869.

1	2	3	4	5						6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of the Experiment.	Date—October, 1869.	Temperature of the Water—Farenheit.	Opening of the Regulating Gate.	TIME.						Duration of the Experiment in seconds.	Total Number of Revolutions of the Wheel During the Experiment.	Number of Revolutions of the Wheel per second.	Weight in Scale in pounds.	Useful Effect, or the Friction of the Brake in pounds, raised one foot per second.	Height of the Water measured in the forebay before entering the Wheel in feet.	Height of the Water in the pit immediately after leaving the Wheel in feet.	Total Fall Acting on the Wheel in feet.	Depth of Water on the Weir in feet.	Quantity of Water which passed the Weir in cubic feet per second.	Power of the Water in pounds raised one foot per second.	Ratio of the Useful Effect to the Power Expended.	Velocity Due to the Fall Acting on the Wheel in feet per second.	Ratio of the Velocity of the outer edge of the bucket to the Velocity due to fall
				Beginning of the Experiment.			Ending of the Experiment.																
				H.	M.	S.	H.	M.	S.														
1	27	45°	Full.	4	56	58·0	4	57	25·0	27·0	100	3·7037	30·0	16647·8	15·590	0·880	14·710	0·8775	27·177	24937·6	0·668	30·760	1 1
2	“	“	“	4	53	7·0	4	56	30 0	203·0	700	3·4482	35·5	18082·5	15·591	0·880	14·711	0·8765	27·137	24902·5	0·726	30·761	1·
3	“	“	“	4	50	20·0	4	52	51·0	151·0	500	3·3112	37·0	18361·9	15·580	0·874	14·706	0·8755	27·087	24848·0	0·739	30·756	0·
4	“	“	“	2	51	14·0	2	57	39·0	385·0	1200	3·1168	40·0	18679·6	15·588	0·864	14·724	0·8735	27·007	24804·8	0·753	30·775	[illegible]
5	“	“	“	4	45	34·0	4	50	4·0	270·0	800	2·9629	42·0	18645·1	15·566	0·870	14·696	0·8711	26·886	24647·4	0·756	30·746	0·
6	“	“	“	3	2	44·0	3	7	33·0	289·0	800	2·7681	45·0	18663·5	15·555	0·860	14·695	0·8693	26·826	24591·2	0·759	30·744	0·825
7	28	43½°	“	4	50	11·0	4	52	41·5	150·5	400	2·6578	46·0	18318·0	15·513	0·875	14·638	0·8666	26·676	24358·6	0·752	30·685	0·794
8	27	45°	“	4	20	14·0	4	24	59 5	285·5	750	2·6269	47·0	18498·3	15·577	0·870	14·707	0,8681	26·767	24556·4	0·753	30·758	0·7
9	28	43½°	“	4	55	14·0	4	57	47·0	153·0	400	2·6143	47.0	18410 0	15·530	0·880	14·650	0·8655	26·636	24341·9	0·756	30·698	[illegible]
10	27	45°	“	4	25	59·0	4	30	44·0	285·0	700	2·4561	49·0	18031·9	15·562	0·870	14·692	0·8668	26·696	24466·3	0·737	30·741	[illegible]
11	“	“	“	3	9	9 0	3	15	4 0	355·0	850	2·3943	50·0	17936·9	15·544	0·862	14·682	0·8650	26·616	24376·2	0 736	30·731	0·714
12	“	“	“	4	35	15·0	4	40	59·0	344·0	800	2·3255	51·0	17769·9	15 552	0·871	14·681	0·8653	26·636	24392·8	0·729	30·730	0·
13	“	“	“	4	42	4·0	4	45	0·0	176·0	400	2·2727	52·0	17707·0	15·560	0 871	14·689	0·8650	26·616	24387·7	0·726	30·738	0·67
14	“	“	“	3	16	17·0	3	21	9·0	292·0	650	2·2260	52·5	17509·9	15·538	0·870	14·668	0·8655	26·636	24371·2	0·718	30·717	0·664
15	“	“	“	3	21	32·0	3	26	8·0	276·0	600	2·1738	52·9	17221·4	15·529	0·870	14·659	0·8635	26·546	24273·8	0·709	30·707	0·64
16	“	“	“	3	27	13·0	3	35	24·5	493·5	1050	2·1073	53·5	16891·9	15·532	0·870	14·662	0·8638	26·556	24287·1	0·696	30·710	0·6
17	“	“	“	3	36	13·0	3	42	12 5	359·5	750	2·0862	54·5	17043·2	15·548	0·870	14·678	0·8642	26·576	24332·4	0·700	30·727	0·622
18	“	“	“	3	43	1·0	3	47	54·0	293·0	600	2·0477	55·0	16874·4	15·547	0·870	14·677	0·8641	26·576	24331·1	0·694	30·726	0·611
19	“	“	“	3	49	10·0	3	54	12·5	302·5	600	1·9834	56·0	16641·7	15·510	0·870	14·640	0·8631	26·536	24233·2	0·687	30·687	0·592
20	“	“	“	3	56	0·0	3	59	54·0	234·0	450	1·9230	57·0	16423·0	15·548	0·870	14·678	0·8635	26·546	24249·4	0·676	30·727	0·
21	“	“	“	4	0	46·0	4	3	29·0	163·0	300	1·8404	58·0	15993·3	15·552	0·866	14·686	0·8632	26·536	24309·3	0·658	30·735	0·54
22	“	“	“	4	4	53·0	4	8	11·5	198·5	350	1·7632	59·0	15586·6	15·560	0·863	14·697	0·8629	26·526	24264·9	0·641	30·747	0·525
23	“	“	“	4	9	9·0	4	10	37·0	88·0	150	1·7045	60·0	15523·1	15·565	0·860	14·705	0·8615	26·456	24267·2	0·631	30·755	0·508
24	28	43½°	¾	4	44	10·0	4	47	29·0	199·0	550	2·7638	40·0	16564·0	15·510	0·798	14·712	0·8350	25·253	23175·8	0·715	30·762	0·
25	“	“	“	4	39	52·0	4	43	52·0	240·0	650	2·7083	41·0	16637·2	15·518	0·850	14·668	0·8352	25·263	23115·6	0·720	30·717	0·
26	“	“	“	4	35	8·0	4	38	17·0	189·0	500	2·6455	42·0	16647·8	15·524	0·850	14·674	0·8350	25·253	23115·9	0·720	30·723	[illegible]
27	“	“	“	4	31	33·0	4	34	48·0	195·0	500	2·5641	43·0	16529·7	15·525	0·850	14·675	0·8341	25·223	23090·0	0·715	30·724	0 7
28	“	“	“	4	27	14·0	4	30	54·0	220·0	550	2 5000	44·0	16481·3	15·536	0·850	14·686	0·8335	25·173	23061·4	0·715	30·735	0·7
29	“	“	“	4	23	27·5	4	26	53·5	206·0	500	2·4271	45·0	16364·4	15·553	0·850	14·703	0·8328	25·143	23060·5	0·710	30·753	[illegible]
30	“	“	“	4	17	37·0	4	22	45·0	308·0	700	2·2727	47·0	16004·4	15·534	0·852	14·682	0·8320	25·113	23000·0	0·696	30·731	0·6
31	“	“	“	4	13	18·0	4	17	14·0	236·0	500	2·1186	49·0	15554·1	15·537	0·860	14·677	0·8312	25·083	22964·7	0·677	30·726	0·
32	“	“	“	4	8	4·0	4	12	30·0	266·0	550	2·0676	50·0	15489·4	15·570	0·863	14·707	0·8296	24·993	22928·9	0·676	30·757	0·
33	“	“	“	3	49	24·0	3	55	38 0	374·0	700	1·8716	52·5	14722·1	15·565	0·868	14·697	0·8273	24·923	22849·0	0·644	30·747	0·558
34	“	“	½	3	41	16·0	3	42	28·0	72·0	200	2·7777	30·0	12485·5	15·580	0·805	14·775	0·7600	21·946	20227·1	0·617	30 828	[illegible]
35	“	“	“	3	36	11·0	3	40	3·0	232·0	600	2·5862	32·0	12399·7	15·585	0·805	14·780	0·7610	21·976	20261·7	0·612	30·833	0·7
36	“	“	“	3	33	7·0	3	35	51·0	164·0	400	2·4390	34·0	12424·8	15·582	0·800	14·782	0·7607	21·966	20254·6	0·613	30·835	0·72
37	“	“	“	3	27	50·0	3	31	22·0	212·0	500	2·3584	35·0	12367·6	15·579	0·800	14·779	0·7590	21·906	20195·6	0·612	30·832	0·70
38	“	“	“	3	43	8·0	3	47	3·0	235·0	550	2·3404	35·0	12273·2	15·585	0·792	14·783	0·7574	21·836	20136·4	0·610	30·836	0·
39	“	“	“	3	22	53·0	3	27	7·0	254·0	550	2·1653	37·5	12166·0	15·580	0·799	14·781	0·7566	21·786	20087·5	0·606	30·834	0·6
40	“	“	“	3	16	58·0	3	21	38·5	280·5	550	1·9607	40·0	11750·9	15·575	0·799	14·776	0·7538	21·445	19766·6	0·594	30·820	0·
41	“	“	“	3	11	25·0	3	16	31·0	306·0	550	1·7973	42·0	11310·1	15·576	0·794	14·782	0·7513	21·355	19691·1	0·574	30·835	0·
42	“	“	“	3	5	3·0	3	10	29·0	326·0	500	1·5337	45·0	10340·7	15·580	0·775	14·805	0·7442	21·275	19648·7	0·526	30·860	0·4
43	“	“	“	3	1	27·0	3	4	27·0	180·0	200	1·1111	49·0	8157·3	15·603	0·754	14·849	0·7308	20·694	19168·2	0·426	30·905	0·
44	“	“	“	2	56	35·0	2	59	51·0	196·0	200	1·0204	50·0	7644·3	15·653	0·748	14·905	0·7292	20·643	19149·7	0·397	30·963	0·
45	“	“	¼	5	14	53·0	5	17	41·0	168·0	400	2·3809	25·0	8918·3	15·670	0·690	14·980	0·6794	18·569	17352·0	0·514	31·041	[illegible]
46	“	“	“	5	11	58·0	5	13	5·0	67·0	150	2·2388	26·5	8889·2	15·643	0·690	14·953	0·6770	18·469	17226·7	0·516	31·013	[illegible]
47	“	“	“	5	8	52·0	5	11	34·0	162·0	350	2·1604	27·5	8901·6	15·646	0·690	14·956	0·6764	18·449	17212·7	0·517	31·017	[illegible]
48	“	“	“	5	6	17·0	5	8	27·0	130·0	250	1·9230	30·0	8643·7	15·650	0·680	14·970	0·6727	18·308	17097·1	0·506	31·031	[illegible]
49	“	“	“	5	1	11·0	5	5	19·0	248·0	350	1·4112	35·0	7400·4	15·653	0·664	14·989	0·6585	17·737	16584·8	0·446	31·050	[illegible]

TABLE OF EXPERIMENTS U

1	2	3	4	5						6	19
No. of the Experiment.	Date—October, 1869.	Temperature of the Water—Farenheit.	Opening of the Regulating Gate.	TIME. Beginning of the Experiment. H.	M.	S.	Ending of the Experiment. H.	M.	S.	Duration of the Experiment in seconds.	Ratio of the Velocity of the outer edge of the bucket to the Velocity due to Fall
1	27	45°	Full.	4	56	58·0	4	57	25·0	27·30	1·10
2	“	“	“	4	53	7·0	4	56	30·0	203·61	1·02
3	“	“	“	4	50	20·0	4	52	51·0	151·56	0·98
4	“	“	“	2	51	14·0	2	57	39·0	385·75	0·92
5	“	“	“	4	45	34·0	4	50	4·0	270·46	0·88
6	“	“	“	3	2	44·0	3	7	33·0	289·44	0·82
7	28	43½°	“	4	50	11·0	4	52	41·5	150·35	0·79
8	27	45°	“	4	20	14·0	4	24	59·5	285·58	0·78
9	28	43½°	“	4	55	14·0	4	57	47·0	153·08	0·78
10	27	45°	“	4	25	59·0	4	30	44·0	285·41	0·73
11	“	“	“	3	9	9·0	3	15	4·0	355·31	0·71
12	“	“	“	4	35	15·0	4	40	59·0	344·30	0·69
13	“	“	“	4	42	4·0	4	45	0·0	176·38	0·67
14	“	“	“	3	16	17·0	3	21	9·0	292·7	0·66
15	“	“	“	3	21	32·0	3	26	8·0	276·07	0·64
16	“	“	“	3	27	13·0	3	35	24·5	493·0	0·62
17	“	“	“	3	36	13·0	3	42	12·5	359·7	0·62
18	“	“	“	3	43	1·0	3	47	54·0	293·6	0·61
19	“	“	“	3	49	10·0	3	54	12·5	302·7	0·59
20	“	“	“	3	56	0·0	3	59	54·0	234·7	0·57
21	“	“	“	4	0	46·0	4	3	29·0	163·5	0·54
22	“	“	“	4	4	53·0	4	8	11·5	198·7	0·52
23	“	“	“	4	9	9·0	4	10	37·0	88·5	0·50
24	28	43½°	¾	4	44	10·0	4	47	29·0	199·2	0·82
25	“	“	“	4	39	52·0	4	43	52·0	240·7	0·80
26	“	“	“	4	35	8·0	4	38	17·0	189·3	0·78
27	“	“	“	4	31	33·0	4	34	48·0	195·4	0·76
28	“	“	“	4	27	14·0	4	30	54·0	220·5	0·74
29	“	“	“	4	23	27·5	4	26	53·5	206·3	0·72
30	“	“	“	4	17	37·0	4	22	45·0	308·1	0·67
31	“	“	“	4	13	18·0	4	17	14·0	236·6	0·63
32	“	“	“	4	8	4·0	4	12	30·0	266·7	0·61
33	“	“	“	3	49	24·0	3	55	38·0	374·7	0·55
34	“	“	½	3	41	16·0	3	42	28·0	72·8	0·82
35	“	“	“	3	36	11·0	3	40	3·0	232·3	0·7
36	“	“	“	3	33	7·0	3	35	51·0	164·5	0·7
37	“	“	“	3	27	50·0	3	31	22·0	212·2	0·7
38	“	“	“	3	43	8·0	3	47	3·0	235·6	0·6
39	“	“	“	3	22	53·0	3	27	7·0	254·4	0·6
40	“	“	“	3	16	58·0	3	21	38·5	280·0	0·5
41	“	“	“	3	11	25·0	3	16	31·0	306·5	0·5
42	“	“	“	3	5	3·0	3	10	29·0	326·0	0·4
43	“	“	“	3	1	27·0	3	4	27·0	180·5	0·3
44	“	“	“	2	56	35·0	2	59	51·0	196·3	0·3
45	“	“	¼	5	14	53·0	5	17	41·0	168·1	0·7
46	“	“	“	5	11	58·0	5	13	5·0	67·3	0·6
47	“	“	“	5	8	52·0	5	11	34·0	162·7	0·6
48	“	“	“	5	6	17·0	5	8	27·0	130·1	0·5
49	“	“	“	5	1	11·0	5	5	19·0	248·0	0·4

The length of the weir was 10·052 feet.

The section of the canal approaching the weir was 14 feet in width, and its depth was 3·26 feet plus the depth of water on the weir.

The leakage into and from the pit was inappreciable, so that the quantity of water passing the weir was the quantity acting upon the wheel.

The quantity was calculated by the formulæ—

$$Q = 3{\cdot}33\ (l - 0{\cdot}2\ H)\ H^{\frac{3}{2}}$$

$$V = \frac{Q}{S} \qquad h = \frac{V^2}{2\ g},$$

$$H' = \left[(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}} \right]^{\frac{2}{3}},$$

$$Q' = 3{\cdot}33\ (l - 0{\cdot}2\ H')\ H'^{\frac{3}{2}}$$

in which—

Q = approximate quantity in cubic feet per second.
l = length of weir in feet.
H = observed depth of water upon the weir in feet.
S = section of the canal leading to the weir $= 14 \times (3{\cdot}26 + H.)$
V = velocity of water in canal leading to the weir.
h = head due this velocity.
H' = depth upon the weir corrected for the velocity due the water approaching the weir.
Q' = quantity of water passing the weir in cubic feet per second.

From this table it will be seen that the mean maximum efficiency of this wheel is as follows, viz:—With full gate $75\frac{9}{10}$ths per cent. of the power of the water; with three-quarters gate, 72 per cent.; with half gate $61\frac{3}{10}$ths per cent.; and with quarter gate $51\frac{7}{10}$ths per cent.

Essex Co.'s Office, Lawrence, April, 1870.

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C.E.

To the President and Directors of the American and Atlantic and Pacific Ship Canal Company.

Gentlemen: Having accepted the appointment of Chief Engineer of your Company, to make a survey and location of a line for the construction of a Ship Canal from the Atlantic, at the harbor of San Juan del Norte, in the State of Nicaragua, to the Pacific Ocean, I, in pursuance of instructions subsequently received, organized an Engineer Corps in the city of New York, and proceeded to San Juan del Norte; thence up the river San Juan, and across the Nicaragua Lake to the city of Rivas de Nicaragua, at which place we arrived on the 27th day of August, 1850.

In relation to the general plan of conducting the survey, the further instructions of your Board are as follows: "The company being informed that there is a practicable route for a ship canal from the Lake of Nicaragua to Salinas Bay, (on the Pacific,) it is desirable that *this line should be first* examined, and if believed to be practicable, surveyed, and if it be a feasible line, no survey from Lake Managua (or Leon) may be required, as the object of the company is to *save expense* by saving distance. If, however, this line cannot be adopted without tunnelling or very deep and long *continued excavation*, you will then preserve your notes (of course) to make and transmit to us an estimate of the cost of the work on this line, and proceed at once to make the survey from Lake Managua to the Pacific, and to such points thereon, *where there is a good harbor*, or such points as in your judgment may be advisable, and continue this until the most practicable route shall be found. You will then ascertain the line through the lake to the River Tipitapa (or Panaloya,) the depth of water, &c.

"After reaching this river, you will, by survey, ascertain the best line to Lake Nicaragua, and whether any part of the river can be used at *less expense* than by canalling the entire distance between the lakes. This done, ascertain the line through Lake Nicaragua to the river San Juan, and thence the depth of water at the *lowest* and *highest* stages down to the rapids of Castillo Viejo. From the last point to San Juan de Nicaragua; ascertain the capacity of the river obstructions, and possibility of their removal, &c. A line without reference to the river, should also be run from San Juan de Nicaragua to the rapids of Castillo Viejo.

"The harbors we wish to have particularly examined.

"In the above instructions, the company do not wish to limit you in your examinations; they wish the most feasible line that exists for the construction of the canal, from ocean to ocean, *surveyed* and *located*, and if these cannot be done in the mode pointed out, *do them in any other.*

"The estimates and surveys we wish to be for a canal of sufficient depth of water for vessels of the largest class, and to combine the *greatest cheapness* with the *greatest durability.* To accomplish these, we do not think it necessary to make the canal of a *uniform width*, but to have it wider in some places, for 'turn-outs,' than in others. The locks must be faced with wood (or timber) to preserve ships from injury.

"We wish no ornamental work, and no estimate for anything not essential to durability and usefulness."

In construing these instructions, their application to any other line leading from the Nicaragua Lake to the Pacific, more direct, and in its other general features more advantageous for the construction and use of a ship canal, than either of those specified, was deemed to be in compliance with their provisions, and although a line so favorable as strictly to fall within the terms of the resolution may not have been found, yet if that selected for survey and location is shorter, less expensive to construct, more convenient and practicable for use than any other upon which a connection of the Lake of Nicaragua with the Pacific Ocean might be formed, the omission of other reconnoissances and the survey of other lines will not, as is believed, be deemed in violation of the spirit of the instructions.

The Lake of Nicaragua, in the direction of its greatest length, lies nearly northwest and southeast. It has an extreme length and width of about 110 by 35 miles.

Its greatest proximity to the Atlantic is near its southerly end, from which, upon a right line, it is about sixty miles distant. The point of its nearest approach to the Pacific is near the middle of its length, where, by the shortest line, the distance across is about 11 miles.

The only outlet of this lake is the San Juan River, which has its issue near the southerly extremity of the lake, at Fort San Carlos, in latitude 11° 1′ 23″, and, after pursuing generally an easterly and a sinuous course a distance of about 119 miles,—receiving considerable accessions from the Rio San Carlos, the Serapiqua, and several others of less magnitude, and again losing much the largest portion of its waters through the Colorado, (a diverging branch connecting with the sea at a more southerly point,)—it enters the Atlantic through the harbor of San Juan, in latitude 10° 56′ 45″ north, and 83° 42′ 19″ west longitude.

About from 15 to 18 miles northwesterly from the Lake of Nicaragua, is the Lake of Managua, having a length variously estimated at from 30 to 45 miles, and an average of 12 or 15 miles in breadth. The only known outlet of this lake is into that of Nicaragua.

Proceeding northwesterly from Costa Rica, a State adjoining Nicaragua on the south, the range of high lands, which at some points rise into lofty mountains in the former State, becomes less elevated and broken, and, on approaching the State of Nicaragua, the general surface falls away into hills comparatively of moderate acclivity and elevation, being in most cases susceptible of cultivation to their summits. This latter description is more especially applicable to that section of country lying between the Lake of Nicaragua and the Pacific, to an extent of over two-thirds the length of the lake. On this distance, and between these two bodies of water, are several transversal valleys extending quite across, with summits varying in height, and furnishing, generally, good opportunities for direct communications by means of ordinary roads, and, in a single instance, what is deemed to be a practicable route for opening a communication by canal. Continuing northwesterly, the hills soon again assume the form of low though continuous mountain ranges, extending along the coast of the Pacific nearly 100 miles, to where they branch off, in some cases into isolated ranges, partaking more the form of diversified hills, which diminish in elevation and gradually subside to the more level lands forming the valley extending from the Lake of Managua to the coast of the Pacific at the port of Realéjo, in about 12° 28′ north latitude.

The elevated lands extending southeasterly from the Gulf of Fonseca, in latitude 12° 50′ north, along the easterly side of the Lakes of Nicaragua and Managua, appear to decline to a lower general level near the southerly termination of the latter lake, and occupy a broad belt of country between the lakes and the Atlantic, from which divergent branches, in some cases of apparently continuous, and in others of isolated, low ranges of hills, terminate at points remote from each other, and in some instances abruptly on approaching the San Juan River.

From the brief topographical description thus given, it will be perceived that the Lakes of Managua and Nicaragua occupy a considerable portion of a great valley extending from the Pacific at the Gulf of Fonseca and the port of Realéjo, southeasterly to a few miles beyond the southerly end of the latter lake, from which, with a general direction more easterly, and embracing within its limits the river San Juan, it continues, with a much contracted width, and with material exceptions to well defined boundaries, to the Atlantic Ocean.

In addition to the ranges of hills before described as terminating on the northerly side of the river, are those bounding the lateral valleys through which flow the rivers San Carlos and Serapaqui, two considerable streams having their origin south, in the high lands of Costa Rica, and flowing northerly, are, as before stated, received into the San Juan; the former 65 $\frac{21}{100}$, and the latter 90 $\frac{25}{100}$ miles from the lake. The valley, on its southerly side, is further intersected by hills lying transversely, and approaching the river at the Rapids of Toro, Castillo, Machuca, and at various other points on either side the river, washes the bases of shorter ranges, and in some instances of isolated conical hills.

From observations, and information derived from other sources, it appeared evident that the construction of a Ship Canal from the Atlantic to the Pacific Oceans, in the State of Nicaragua, could not be considered practicable upon any route other than that through the valley of the San Juan River to the Lake of Nicaragua, and from that lake either southwesterly upon a line through some valley extending across the dividing ridge, or northwesterly up the Rio Tipitapa to the Lake of Managua, thence through the valley extending from the head of that lake to some feasible point for a connection with the Pacific. In view of the much greater length of canal that would be necessary on this latter route, and the greater amount of lockage required, as the lake of Managua was supposed to be near 30 feet higher than that of Nicaragua, and more especially the greater expense and uncertainty of obtaining a full supply of water for that more elevated summit, it was deemed important at least so far to explore the country between the westerly side of the lake and the Pacific, as would be necessary to determine whether a practicable route existed upon which the canal might be constructed directly across to some feasible point for a connection with the Pacific.

With these general impressions, and in pursuance of the special instructions, a reconnoissance was first made of that part of the country lying in the department of Guanacaste, between the lake at the mouth of the Sapoa River and the Pacific at Salinas Bay. The valley thus examined lies the most southerly of any offering the remotest prospects of affording a practical line for a canal.

The Sapoa River rises at the head of a valley extending south from the southwesterly side of the lake far into the interior, having the high lands skirting the Pacific south from Salinas Bay, on the west, and the Costa Rica mountains, a continuous and much elevated range, on the east.

A much inclined valley, about 1½ miles in width, extends back from the head of the bay about 3 miles, and terminates at the base of a precipitous surface, extending up to the verge of table lands elevated about 1000 feet above the bay. From this eminence, the general surface, with much uniformity, descends in an easterly direction, forming the eastern slope of an improved portion of the broad valley of the Sapoa River.

A line of level was commenced at the surface of Salinas Bay, at low tide, and carried back over a surface ascending uniformly to an elevation of 200 feet, in a distance of 2¾ miles to the northeast corner of the valley, thence bearing to the left, the level was extended northeasterly up an irregular narrow ravine, bounded by high projecting spurs, a further distance of 0 $\frac{66}{100}$ mile to the summit, having an elevation of 534 feet above the bay. This summit has a length of about 4 chains, and a width only about equal to that required for a canal, and is bounded on either side by precipitous surfaces, extending up some 4 or 500 feet to the general level of the table lands, before alluded to. Proceeding from the summit easterly down the opposite plane, in the direction of the lake, the level was extended about 5 miles, to within a few chains of the Sapoa River at a point 432 feet above low tide in the bay, and to which, by means of a low dam and short embankment, the waters of the Sapoa might be readily conveyed and conducted thence to the summit level of the canal. By establishing the summit level at this elevation a cut would be required 119 feet in extreme depth, the surface gradually falling down to the bottom plane of the canal on the Pacific side, in a distance of 15 chains, and on the opposite or lake side, in about 4½ miles; an ascending lockage from the lake of 320·53 feet, and 432 descending lockage to the Pacific would be necessary to pass this summit.

A permanent supply of about 4000 cubic feet of water per minute would be furnished by the Sapoa River, and any additional quantity that might be required for the use of the canal, could be made available by reservoirs constructed on sites unusually favorable for that purpose.

From the junction of the line with the Sapoa River to the lake, a distance of about 14 miles, no instrumental examinations were made. From observation, however, and information obtained from other sources, the opinion is entertained, that at least ordinary facilities exist along the valley of the Sapoa for the construction of a canal, especially when considered in connection with that part of the line which would occupy the broad and sufficiently deep channel of the river, a distance extending back inland from the bar in the lake, about four miles.

Among the most unfavorable features connected with the construction of the canal upon this line, is the magnitude of the cut required through the summit, the expense of which would be enhanced by the long haul necessary in depositing the material, the large amount of lockage required, the great expense of introducing to the summit a full supply of water, the expense of constructing and the disadvantages in use of that part of the line extending from the summit west, arising from the many sinuosities, the rugged borders and rapid descent of the ravine—the latter involving the necessity of combinations of locks; also the long cut (nearly ¾ of a mile in rock) that would be required from the margin of the bay of Salinas to deep water. The unfavorable features in the ravine descending west are such as scarcely render this a practicable route.

Another transversal valley, about 3½ miles westerly from Rivas de Nicaragua, with an apparently low summit, was examined by running a line of level from the surface of the lake east of Rivas, westerly upon the most direct route, over an inclined though moderately undulating plain, ascending 326 feet in a distance of 6½ miles, to the summit of a broad valley, passing between the hills (which are here of moderate height) and connecting with another valley on the west side, which by a very direct line extends to the

Pacific at the harbor of Brito. The quantity of water available for this summit being entirely inadequate, and the cut altogether too formidable on the plan of carrying the lake level through to the western slope, this route was abandoned, and the level was extended about $3\frac{1}{2}$ miles north to another depression in the ridge, elevated 198 feet above the surface of the lake. Proceeding from the lake west upon a line passing the ridge at this point, the surface, with much uniformity, rises 60 feet in the first distance of about $4\frac{1}{2}$ miles, 34 feet in the next $1\frac{3}{8}$ miles, 50 feet in the succeeding 81 chains, thence to the culminating point in this pass, a further rise of 54 feet occurs in 30 chains, making a total rise of 198 feet in the aggregate distance of $7\,\frac{26}{100}$ miles. Continuing the level from the summit west, the surface was found to descend 130 feet in 86 chains, and to fall to the level of the lake in a further distance of 30 chains or 1 36-80 miles from the summit, thus showing that a thorough cut of 198 feet in extreme depth, and $8\,\frac{71}{100}$ miles in length, exclusive of the additional depth necessary for the canal, would be required on the plan of carrying the lake level through to the western slope of the ridge, forming the eastern boundary of the Chocalape Valley, which, uniting first with the valley of Rio Tolo, then with that of the Rio Grande, also reaches the Pacific at the harbor of Brito in a distance of about $11\,\frac{19}{80}$ miles, making the whole distance from the lake to the Pacific, by this route, about 20 miles.

Proceeding northerly from the line above alluded to, the lines of the coast of the Pacific and of the lake severally diverge, giving a corresponding increase to the width of the territory between them; the moderately inclined and fertile plain skirting the western border of the lake nearly its entire length, assumes more expansive limits, while the hills bounding the Pacific appear continuous and of greater elevation, thus presenting obstacles regarded as too formidable to justify further explorations of the country extending from the line last described to the north end of the lake.

The line of level was next carried to the summit of a transversal valley, lying about $6\frac{1}{2}$ miles south of Rivas de Nicaragua, between the Rio Lajas, emptying its waters into the lake about $1\frac{1}{3}$ miles north of Virgin Bay, and the Rio Grande which flows into the Pacific at Brito Harbor. This summit was found to be $47\frac{1}{2}$ feet above the surface of the lake, as it stood on the twenty-third day of December, 1850, at which time it was 3·43 feet above its lowest stages, or that to which it subsided in April last, and $1\frac{57}{100}$ feet below the elevation at which it ordinarily stands during the latter part of the wet seasons.

From a general view of the country through which the line upon this route would pass, it appeared evident that but little rock excavation would be encountered west of the western termination of the summit level, that the surface would generally be favorable, and as was represented the length of the line would not exceed 20 miles.

The following information in relation to the route extending from the northerly end of the Lake of Nicaragua through the Lake of Managua, thence to the harbor of Realéjo, is furnished by the report of the surveys made in 1837 and 1838, under the patronage of the government of Central America, by Mr. John Bailey, an English engineer, and from other sources, as published in the United States Congressional Document entitled "Rep. No. 145," by Hon. John A. Rockwell, from the select committee, &c., under date of February 20, 1849. From this document it appears, (see page 597,) that "the Lake of Managua," here called "Leon," "is 28 feet 8 inches above the level of that of Nicaragua," and that "the most elevated point of land between the Lake Leon and Realéjo is 55 feet 6 inches above the level of the lake;" and on pages 604 and 605 it is stated that "up to the present time, the general opinion of competent persons who have devoted their attention to the junction of the two seas through the State of Nicaragua, is, that the canalization of the rivers San Juan and Tipitapi offers no extraordinary difficulty. The only important point to ascertain was the elevation of the land between the Lake of Leon and the Pacific. We have seen that the engineers agree in representing this elevation as not being considerable. Dampeir, Stephens, Rouhand and Bailey contend that the country gradually declines to the ocean; according to other informants the highest ground is $49\frac{1}{2}$ feet above the Lake of Leon, but Mr. A. G.****, who explored the country in 1842, has accurately investigated its formation, and has furnished us with the following particulars:

The western coast of the Lake of Leon is 26 feet above the lake: from thence the land rises gradually for a distance of 2,725 yards, (or $1\frac{55}{100}$ miles) to an elevation of 55 feet 6 inches; here is then the culminating point whence the ground gently descends to the ocean.

"At a distance of eleven miles from the western shore of the lake, on the line which the canal should take to join Realéjo, we find the River Tosta," (presumed to refer to the River Tolita,) "which at this spot is 34 feet above the lake."

The distance from this river to where the plain of the ground surface falls down to the level of the lake, is not given in the report. Admitting, however, as an approximation, that the inclination from the river, in the direction of Realéjo, is the same as that from the summit to the river, then the ground surface would meet the level of the plain of the surface of the lake if extended $14\frac{94}{100}$ miles beyond the River "Tosta," or $24\frac{39}{100}$ miles west from the summit. The distance from the lake to the summit being given at $1\frac{55}{100}$ miles, it appears probable, that with the addition of the requisite depth for the canal, the length of deep cutting on this superior level would be at least $25\frac{94}{100}$ miles; that its extreme depth would be as before stated, $55\frac{1}{2}$ feet exclusive of that required for the canal.

In relation to the River Tipitapa, the following is found on page 603 of the report above alluded to: "The Lake of Nicaragua," says Mr. Bailey, "is connected with that of Leon by means of the River Panaloya, (or Tipitapa,) navigable for the boats employed in that country for twelve miles, as far as the place called Pasquiel, where the inhabitants go to cut and bring away Brazilian timber. The four miles which remain between that place and the Lake of Leon are not navigable for any kind of boat, whatever be its construction, because, beyond Pasquiel the channel is obstructed by a vein of rocks, which, when the river is swollen, are covered with water, but in the dry season the water sinks so low that it can only escape through gradually diminishing fissures in the rocks. At a distance of a mile beyond this first vein of rocks, we find another more solid, which, crossing the river at right angles, forms a cascade of 13 feet descent." "The River Tipitapa, which discharges into the Lake of Nicaragua, is the only outlet for the Lake of Leon."

On the 15th of April last, without the use of instruments, I examined with care that portion of the River Tipitapa extending from the Lake of Managua to the place Pasquiel, referred to by Mr. Bailey as the "depot of Brazilian timber." This point, as nearly as could be estimated, is about 5 miles from the lake, and below all the rapids that occur in the river. It being near the close of the dry season, the lake was supposed to be about at its lowest stage, and was found depressed several feet (say from 4 to 6) below the crest of the first fall, which occurs in the bed of the channel of the outlet, about one mile from the lake, consequently no water, at the time of the examination, passed this point.

The channel, as far down as examined, has a width of say from 3 to 4 hundred feet, with banks of regular form from 6 to 10, and in some instances of a greater height. Proceeding down or southerly from the point of maximum elevation in the bed of the outlet, a descent of 1 or 2 feet occurs in a distance of half a mile. Here it has a vertical fall of from 12 to 15 feet; thence a fall about the same in the aggregate occurs in the succeeding distance of about $3\frac{1}{2}$ miles to Pasquiel, by which is formed a succession of rapids with short intervening levels, containing pools of water, formed by springs issuing at the margin, and at other places through fissures in the rock.

From Pasquiel to the Lake of Nicaragua, a distance variously estimated at from 12 to 15 miles, the water in the outlet is probably upon the same level as that of the lake, its channel appears a little wider than above Pasquiel, and is said to be navigable with boats drawing 2 to 3 feet water: portions of the distance have, probably, a greater depth. It passes through a small lake with shoal water lying near the northerly end of Lake Nicaragua. The excavation upon that portion between the Lake of Managua and Pasquiel would be almost entirely in rock; the country being quite level between Pasquiel and Lake Nicaragua and a portion of it sufficiently elevated, a part of the distance would be favorable for the construction of a canal, the remainder would probably be expensive.

From the extract before given of the remarks of Mr. Bailey in relation to the flow of water in this outlet, it appears that the Managua Lake must have stood at a greater elevation when examined by him, or the elevation adopted for the lake, and with which the height of the summit north of that lake was compared, was greater than that at which it stood when examined in April last. If this view be correct, then it would seem inevitable that either the restoring to, and maintaining the surface of the lake at, an elevation equal to that of the crest of the first fall in the outlet would be necessary, or that an addition to the depth of cutting, equal in amount to the depression of the lake surface below the crest of said fall, say from 4 to 6 feet, must be made through the summit connected with, and extending north from, the lake. The former might not be practicable, and the latter would evidently be attended with much additional expense.

By a recapitulation of some of the principal elements of cost before given, and which would be encountered by the construction of the canal upon this route, between Nicaragua Lake and the Pacific, it would appear probable that the canal between the lakes of Nicaragua and Managua would have a length of about 20 miles, that it would be constructed independent of advantages derived from the adoption for the line of any portion of the River Tipitapa, and that an ascending lockage of 28½ feet would be required to reach the latter lake, admitting it to be maintained at the same elevation that it had when examined by Mr. Bailey: and from the Lake of Managua, in the direction of the Pacific, the lake or summit level would occupy about 26 miles, upon which an extreme depth of 55½ feet of cutting would be required, and if the bottom plane of this thorough cut should be lowered, as would probably be necessary, at least sufficient to correspond with the depressed surface of the lake, then an amount equal to this depression below the culminating point of the bed of the outlet would, necessarily, be added to the depth of cutting upon the entire length of this level.

Thus showing that, upon this route, the construction of over 46 miles of canal would be necessary to open the communication between Lake Nicaragua and the Pacific, there would be, independent of that portion of the distance occupied by the Lake of Managua, a summit level 26 miles in length, with an extreme depth of over 55 feet of cutting, exclusive of the contingent additional depth before mentioned, and that required for the depth of water in the canal; and it would involve an excess of 57 feet of ascending and descending lockage beyond that which would be required on the plan of making the Lake of Nicaragua the summit level of the canal.

Having, from personal examinations, formed the opinion that the general features of the country, affecting the feasibility of constructing the canal between the lakes of Nicaragua and Managua, were no more favorable than had been represented, there appeared to be no good reasons for regarding existing facilities for the construction of that beyond the Lake of Managua, not examined by the undersigned, with more favor than representations from the same sources seemed to justify.

(To be continued.)

RESISTANCE TO MOTION OF SHIPS.

By John Lowe, Second Assistant Engineer, U. S. N.

Does the force propelling a vessel vary with the 1st, 2nd, 3rd or nth power of the speed?

There is much difference of opinion upon this subject; some holding, that the force varies with the square, others, with the cube of the speed, while some hold that the resistance of the water to the vessel varies with the square of the speed, while the power necessary to overcome that resistance varies with the cube of the speed.

It is hardly worth while to investigate the subject of power and speed until this first condition is firmly fixed.

Without entering into argument as to which of these is true, it is proposed in the following to show how by the simple experiment of running a vessel against a stream, this subject may be placed beyond controversy.

We will first assume the power to vary with the square, and ask, What is the most economic speed against a current under this condition?

Let $c =$ a co-efficient suitable to a particular vessel:
" $u =$ power required to propel the vessel x knots per hour:
" $x =$ speed of the ship through the water:
" $v =$ speed of the current:
Then $(x-v) =$ net speed of the ship:

$$u = cx^2$$

$$u' = \frac{cx^2}{(x-v)} = \text{Power expended in advancing the vessel}$$

1 knot net against the current, which we require to be minimum.

Differentiating; $\frac{du}{dx} = \frac{2\ cx\,(x - v) - cx^2}{(2 - v)^2} = 2\,x\,\frac{-x^2}{(x - v)} = O$

Whence $2x - 2v = x$, or $x = 2v$

That is, if the power varies with the square of the speed, then the most economic speed against a current is, twice the speed of the current.

Similarly it may be proved, if the power varies with the cube of the speed, then $1\frac{1}{2}$ times the current is the economic speed. If $u = cx^4$ then $x = 1\frac{1}{3}\ v$, etc. etc.

This much proved. The experiment is simply in running a vessel twice as fast, $1\frac{1}{2}$ times as fast, $1\frac{1}{3}$ times as fast, etc., as the current. Then the most economic power, that is, the power and speed producing the best results per knot advanced against the current, will indicate, in an unmistakeable manner, which is the correct function.

The vessel chosen should be small, and therefore inexpensive to operate, easily and quickly handled, and the revolutions of the engines should be under complete control.

Magic-Lantern Pictures on Gelatine by a New Method.—At the last meeting of the Franklin Institute, the Resident Secretary, Prof. Morton, exhibited in the lantern some pictures on gelatine, prepared in a manner devised by Mr. Sheperd Holman, a member of the Institute.

For this purpose a sheet of gelatine such as is used for tracing by engravers, was securely fixed over an engraving, and with a sharp steel point, (made by grinding down the end of a small round file,) the lines of the original traced pretty deeply on the transparent substance. Lead-pencil or crayon dust was then lightly rubbed in with the finger, and the picture was at once ready for use.

A number of such drawings could be easily carried between the leaves of a book, could each in succession be in a frame or cell made of two plates of glass separated by a frame of thin card or three edges and united by paper or muslin pasted around the same edges. The effect of these drawings in the lantern was excellent, and their ease of production very great.

EXPERIMENT ON THE EVAPORATION OF A CORLISS BOILER.

By James B. Francis, Civil Engineer.

The experiment was made on one of the four Corliss Boilers in the mills of the Merrimack Manufacturing Company at Lowell, Massachusetts, constructed by the Corliss Steam Engine Company of Providence, R. I., and first put in operation in October, 1868.

Each boiler consists of a central cylinder, about twenty-four feet high and forty-two inches in diameter, standing vertically on the floor of the boiler house, and containing no tubes or flues, but surrounded by an annular grate, about twelve feet in diameter, with eight fire doors on its exterior circumference. Hanging vertically from the sides of the central cylinder, are six other cylinders, about fourteen feet long and forty inches in diameter, each containing sixty-one vertical tubes, two inches internal diameter, and about fourteen feet long. Each of the tubular cylinders is connected with the central cylinder by three pipes, about seven inches long; those near the top and bottom of the tubular cylinders being about nine inches in diameter, and the intermediate pipe, which is a little below the usual water line, is about fifteen inches high and six inches wide.

The usual height at which the water is kept is at the fifth gauge cock, which is about three feet below the tops of the tubular cylinders, and about nine feet below the top of the central cylinder.

The products of combustion rise on the outsides of all the cylinders to within about two and a half feet of the usual water line. There is, however, no outlet for the gases except through the three hundred and sixty-six tubes in the tubular cylinders; the lower eleven feet of the length of the tubes being usually surrounded by water, and the upper three feet by steam. After passing through the tubes the gases enter a chamber concentric with the central cylinder, and extending about fourteen feet above the top of the tubular cylinders, giving just sufficient height to take out the tubes. From near the top of this chamber the gases pass off by a horizontal flue of sheet iron, about six feet wide and one foot high, to a chimney, two hundred feet in height.

The seven connected cylinders forming the boiler are enclosed by a cylindrical wall of brick work, which confines the gases and supports the feed water tank. The draft is regulated by means of a damper in the horizontal sheet iron flue, and by the eight ash pit doors, which are well fitted and open into a common ash pit. Usually, one of these doors was open from a quarter to a half, and the damper in the flue also open about one half. The fire doors were made of two parallel plates of iron, two or three inches apart, with six air-holes, three-eighths of an inch in diameter, through the outer plate, and a greater number through the inner plate; said to be for the purpose of preventing the doors from becoming too much heated. The powerful draft causes a large quantity of air to pass through these holes and enter the space above the fire, apparently much in excess of what is necessary for the combustion of the gases.

The top of the chamber is covered by an open tank about eighteen inches deep, in which the feed water is usually heated, but which was not used for that purpose in this trial.

The passage of the heated gases over surfaces of the boiler above the water line, of course, tended to superheat the steam, and observations of the temperature of the steam, as well as its pressure, were made to ascertain the amount of the superheating.

The amount of the heating surface, not including the feed water tank, is as follows:

	SQ FEET.
Area of heating surface on outside of the seven cylinders, connecting pipes, &c	1277·56
Tube surface	2679·01
Total heating surface	3956·57
Area of grate surface	103·27
Fire surface to each square foot of grate surface	38·31
Usual thickness of fire six to eight inches, average about	7 inches

For convenience of feeding with water from the water tank, the northeasterly boiler was selected for trial. I am informed that this boiler has been in use uniformly since it was first started, stopping regularly with the others, one week in four, for cleaning and examination. It was stated by Mr. Austin, the engineer in charge, that this boiler was blown off last four or five weeks before the commencement of the trial. It had been stopped one week in its turn just previous to the commencement of the trial, during which time the water was drawn out of it, and the fire surfaces of the tubes and other parts cleaned; nothing, however, being done beyond the usual monthly cleaning.

The trial consisted in measuring the quantity of water evaporated, and weighing the coal burned, during one hundred and twenty hours of continuous firing, from Monday, March 21st, 1870, at noon, to the following Saturday at noon. It was designed to maintain the firing and pressure of steam uniformly, night and day, throughout the trial, but it was not found to be convenient to maintain the pressure fully during the night; the mean pressure during the day being about 68·60 pounds above the atmosphere, and during the night about 65·02 pounds. Fire was made up under this boiler early in the morning of Monday, March 21st. The usual custom is to clean out the clinkers from the grate and make up the fire at eleven o'clock, A. M., which gives a fire in its best condition about one hour afterwards. This was done in this trial, and the water brought to the usual height of the fifth gauge cock at noon, when the trial commenced. All the ashes were then removed from the ash pit, and all the coal in the vicinity of this boiler removed from the floor, and the coal weighed out for the trial put in its place. At the end of the trial the firing was done, as nearly as practicable, in the same manner, the fire being left in its best condition, with the usual quantity of coal on the grate, and the water at the fifth cock.

The quantity of water evaporated was measured in a large wooden tank, constructed for the purpose of heating water for use in the Calico Print Works of the establishment, with part of the exhaust steam from the engine. For this purpose it was detached from its usual connections, and connected only with the force pumps supplying this boiler. The contents of the tank for the five feet in depth, gauged by measurement for this purpose, was 3316·24 cubic feet. This quantity was not all used before refilling. It was filled up five times during the trial, or once each day, and the quantity drawn from each filling noted. The whole quantity drawn was 11405·017 cubic feet, at the mean temperature of 37·97° Fahrenheit, or 711456·37 pounds; allowance being made for a small leakage, and for a slight enlargement of the tank when filled, the dimensions having been taken when empty.

The coal used was white ash anthracite, from the Preston and Gilberton mines, taken from a lot of about fourteen thousand tons received during the year 1869; part of it was exposed to the weather and part of it stored under sheds. It was taken without selection, but I have learned, subsequently to the trial, that about half a ton of slaty lumps was thrown out in the boiler house, and an equal quantity of purer coal substituted. The coal was weighed on platform scales, two tons at a time; the scales having been previously adjusted to weigh accurately, by the official sealer of weights and measures for the City of Lowell.

The total amount of coal weighed out for the trial was		85120 lbs.
Of this, not put on grate	2076 lbs.	
Cinders picked out from ashes at end of trial, that might have been burned, but could not conveniently be returned to the grate during the trial	1112·5 "	3188·5 "
Total amount of coal burned		81931·5 "

The temperature of the feed water was observed in the feed pipe near the force pumps, by a thermometer, the bulb of which was inserted in the pipe and exposed to the current, the scale projecting through a packed joint. The pressure of the steam was observed by an Ashcroft gauge in the steam pipe between the boiler and the first valve. The temperature of the steam was observed in the steam pipe, close to the pressure gauge, by means of a thermometer inserted in a tube filled with oil, fitted into the pipe. The temperature of the gases escaping from the boiler was also observed by means of a similar tube, filled with oil, inserted in the sheet iron flue, about ten inches from the chamber over the boiler. The temperature of the air in several places was also observed. All the thermometers used have been tested since the trial by Huddleston, the well known thermometer maker, of Boston, and the pressure gauge by the American Steam Gauge Company, of Boston. In the results given the corrections have been applied:

Mean temperature of water in feed pipe, (extremes 41·6° and 36·5,)	37·97°
Mean temperature of steam in steam pipe, (extremes 322° and 294°,)	311·8°
Mean pressure of steam in steam pipe, above the atmosphere, (extremes 79 lbs. and 45·5 lbs.,)	66·46 lbs
Mean temperature of gases in flue, (extremes 355° and 208°,)	286·4°
Mean temperature of air in boiler-room, at thermometer 5 feet above floor, (extremes 82·5° and 55°)	73·4°
Mean temperature of air in boiler-room, at thermometer 40 feet above floor, (extremes 130·5° and 107·7°,)	117·7°
Mean temperature of air outdoors, in shade, (extremes 51° and 19°,)	33·9°
Water evaporated from the initial temperature of 37·97° by each pound of coal $= \frac{711456\cdot37}{81931\cdot5} =$	8·684 lbs

To reduce this to the evaporation from 212°, I use the formula given by Rankine, at page 254 of his *Manual of the Steam Engine*, viz.: $h_{2\cdot1} = 1092 + 0\cdot3\ (T_1 - 32^\circ) - (T_2 - 32^\circ)$. In which, $h_{2\cdot1}$ = The multiplier of the observed weight of water evaporated by each pound of fuel, which, being divided by 966, gives the weight of water which would have been evaporated by each pound of fuel, had the water been both supplied and evaporated at the boiling point corresponding to the mean atmospheric pressure.

T_1 = the temperature of evaporation, (see below,) . . . . 299·46°

T_2 = the temperature of the feed water, = ... 37·97°

Substituting the values for T_1 and T_2 we have $h_{2\cdot1}$ = . 1166·27 and the equivalent amount of water, if supplied and evaporated at $212^\circ = 8{\cdot}684 \times \frac{1166{\cdot}27}{966} =$ . . . . 10·484 lbs.

As above described, the boiler is so constructed that the heated gases all pass through the tubes, the upper three feet of their length being above the water line. The exterior of the upper nine feet in height of the central cylinder, which is steam space, is also exposed to the heated gases. The effect of this arrangement being, of course, to superheat the steam.

The observed mean pressure of the steam, per square inch, above the atmosphere, was	66·46lbs.
The temperature of saturated steam, of this pressure, according to Regnault, as given in the table in the *Description of Richard's Improved Steam Engine Indicator*, by Charles T. Porter, London, 1868, is	299·46°
Mean observed temperature of the steam	311·80°
Excess of the observed temperature, being the amount the steam is superheated	12·34°

The superheating being part of the useful effect of the fuel, its equivalent in evaporation of water should be added to the results obtained above.

The specific heat of steam being, according to Rankine, 0·475, that of water being 1. The equivalent evaporation of water from the initial temperature, due to the superheating,

is $\frac{0{\cdot}475 \times 8{\cdot}684 \times 12{\cdot}34}{1166{\cdot}27} =$ . . . . 0·044 lbs.

which added to 8·684 lbs., gives for the equivalent evaporation from the initial temperature . . . . 8·728 lbs.

The equivalent evaporation from 212°, due to the superheating,

is $\frac{0{\cdot}475 + 10{\cdot}484 \times 12{\cdot}34}{966} =$ . . . . 0·064 lbs.

which, added to 10·484 lbs., gives for the equivalent evaporation from 212° . . . . 10·548 lbs

When in ordinary use, the temperature of the feed water is sensibly raised by passing through the tank over the boilers: this is, of course, part of the duty of the boiler, and its equivalent in evaporation should be added to the above in order to give the total evaporative power of the boiler. In this trial the feed-water was not so heated, and I have no means of ascertaining to what extent it would have been heated if it had passed through the tank in the usual manner; I therefore do not attempt to allow for it.

The amount of clinkers was	3261·0 lbs.
" " ashes "	1322·5 "
Amount of clinkers and ashes not returned to the fire	4583·5 "

or about $5\frac{1}{2}$ per cent. of the coal burned.

Lowell, May 5, 1870.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress.

By J. Richards, M. E.

(Continued from page 313.)

Saws and Sawing Machines.

Saws for dividing and reducing timber can, next to the axe, lay claim to the greatest antiquity, in fact no clue exists to establish the first use of reciprocating saws, unless it is found in the records of Asiatic civilization. The antiquity of saws cannot be accounted for in the simplicity of the device, for we find the reciprocating saw in use centuries before the idea occurred of a continuous cutting motion with a circular plate, which, aside from the mechanism to drive it, could be considered but a simple transition from the reciprocating saw; in other words, the reciprocating saw as an original device was a greater invention than the circular saw, as a modification of the original.

To consider saws in the order of their application to wood manufacture, we must begin in the forest mills, at least for the United States, where our lumber is reduced from the log before it goes into the market.

Timber cutting saws may be classed into sash saws, single or in gangs, Muley saws and circular saws. The first is the standard mill of our forefathers, and is yet the only successful plan of operating "gangs." It consists in straining or stretching the saw-plate or plates in a rectangular frame that surrounds the log, connected at its bottom or top with the driving power by means of a crank. The range and speed of movement should be arranged with reference to the depth of the timber, as reciprocating saws can only work well when the range of their movement is as great, or nearly as great, as the depth of the timber to be cut,—a stroke of 30 inches with 150 motions per minute may be considered an approximate standard for "sash saws," as they are technically termed. This gives but 375 feet of cutting movement per minute, or say 350 of effective movement, and contrasts very unfavorably with the circular saw moving as many thousands of feet, or even the muley at twice this speed.

The weight of the reciprocating parts of course must limit the speed, a condition that no doubt led to the invention of the muley mill where the sash is dispensed with. As the traveling speed of the teeth of any saw is the exponent of its performance, it is easy to see that the sash saw could only compete with its more rapid rivals by increasing the number of saws, this being equivalent to increasing the speed with the difference in its favor that it was only limited by the strength of the machinery, and the power to drive it. Thus we find that saw-mills as well as all other machines must obey the inevitable laws that govern their performance, and that final results are as much to be predicated from mathematical deduction as from actual experiment. The sash saw mill maintains its supremacy when its cutting movement is greater and is superseded by its rivals whenever this condition is not fulfilled.

The "roller gang mill" is perhaps the most expeditious and perfect means yet devised for reducing logs to boards. A circular saw for squaring and edging with a strong gang sash, is the machinery of a first class lumber mill of our day. The great mills on the Falls of St. Anthony in Minnesota, and on the St. Croix in Wisconsin have this equipment. The saws are arranged in the sash at proper intervals to give the required thickness of stuff, and the logs feed through continuously by rollers, which give the technical name of "roller gang" to mills of this class.

The muley mill consists of a single saw connected directly with the crank, guided above and below the log by traveling cross-heads. The saw is not strained but depends upon the rigidity of the plate to keep it in line.

In addition to the traveling cross-heads to which each end of the saw is attached, it is supported by fixed guides above and below the log in such a manner that, when cutting, but little of the plate is exposed.

The rigid guides prevent the saw from deviating in its course, and the best grades of lumber as to regular dimensions are produced on muley mills.

The light weight of the reciprocating parts enables these saws to be driven at a high speed compared with the strained or sash mill,—their capacity being greater, their construction more simple and their first cost less, they have come into favor and general use in the pineries of Michigan.

Another important advantage is the portable character of these mills, although not self-contained, the "plant" or permanent connections are not expensive, and for forest sawing the mill can at small expense be moved to the timber as it is cut away, it being less expensive to transport timber than the logs in their rough state.

The movement of the saws is from 700 to 1,000 feet per minute, the crank shaft making from 300 to 400 revolutions per minute. These mills are, for greater simplicity, often built "single-geared," that is, with a steam engine connected directly to the shaft, and running at the same speed as the saw or rather making the same number of revolutions with a reduced piston movement.

The muley saw is, so far as we know, a purely American invention. It would be safe to infer that its invention grew out of a regular train of experiments, for no one would, from any theoretical deduction have ever arrived at the conclusion, that an unstrained saw could be successfully applied to lumber cutting. Many important patents have been granted to inventors for improvements in muley saws, appliances for guiding and giving rake to the saw, &c., and they have attained a high degree of perfection, but the limits of these papers will not admit of a consideration in detail.

Circular saw mills for lumber cutting and forest use are of comparatively recent date, and when we consider their now almost universal application to the purpose and that the circular saw itself has been for more than a century well known, we must look beyond the simple idea of application for a reason for their comparatively recent development.

Such a reason is, without doubt, to be found in the difficulty of following true lines with the circular plate. The least difference in temperature between the eye and periphery, destroys its rigidity which, together with knots, and the irregular grain of the wood, made it almost impossible at first to operate one of these mills. Sawyers who had, from observation and skill, acquired the art of "running a circular mill" were in demand at high wages, but experience in time overcame all obstacles, and while it is yet an art of no mean pretensions to run large saws in rough timber, the "mysteries" of the profession have disappeared. The different manufacturers of circular saw-mills yet differ as to the principles of their operation, as to the lateral play of the plate, the nature of the guiding apparatus, &c., but the practicability is no longer a question. The English manufacturers have not, until within the last two years, given much attention to circular saw-mills for forest purposes, but a demand for mills to go to Australia, Canada and other provinces, has led to the construction of some mills of this kind by Allen, Ransome & Co., of London, and others. It is but fair to anticipate that with their greater experience in operating circular saws in dry timber they will introduce some improvements not known here, and while speaking of circular saws it will perhaps be important to note some of the pecularities of their machines for sawing.

Lumber in England does not, as a rule, come to market reduced to boards and planks as in this country, but generally in the squared log. A planing mill or other wood-working establishment has to be fully equipped for sawing out the stuff, as well as dressing it.

The circular saw bench, then, from this cause, becomes the first and leading machine, instead of an adjunct as here, and this accounts for the large number that are advertised and sold and the strong manner in which they are built—a matter that often puzzles our American manufacturers.

The saws used are upon an average only *one-half* the thickness of those used here. Saws of 36 inches diameter are often made from 14 gauge steel. They are kept cool, lubricated and guided by "packing boxes," which, so far as the writer knows, have never been used in this country. The common plan of constructing them is to form a long chamber in the framing along the side of the saw-plate, extending from the collars to the teeth. A strip of wood lapped with fibrous packing is pressed into this chamber, and, being saturated with oil, serves the several purposes before mentioned. These chambers or packing boxes are sometimes placed both behind and in front of the mandril but generally only on the front, on both sides of the plate. They are covered by removable plates, and add but little to the cost of making the machines. For small saws, when they are often changed on the mandril, of course, these packing boxes would be unnecessary and inconvenient, but for large saws they serve an important purpose.

The circular saw is perhaps the only rotary wood-cutting appliance that has a definite standard for speed. A proposition of this kind will no doubt be new to many of our mechanics and manufacturers and yet will be confirmed by the experience of all.

A circular saw-plate, started with a gradually increasing velocity, will become stiffer and more rigid until a certain degree of velocity is attained; beyond that the rigidity diminishes until at a very high speed, the plate becomes as pliant and limber as a piece of paper, assuming a waved shape on the periphery and yielding to the slightest touch. This forms an interesting experiment, and one that furnishes full information as to the speed of saws, leaving out the question of the material to be sawed. These conditions are, of course, dependent upon the thickness of the plate, the tem-per, the diameter of collars, &c., so that no fixed rule is possible as to speed; but, as an approximate standard, the teeth of circular saws may move 7,000 feet per minute.

Between hard and soft wood, the same conditions that apply to metal-cutting tools should be observed, "the harder the material the slower the speed," the temperature at the cutting point giving a limit for the speed. Large saws can also be run faster than small ones, the greater distance traveled by the teeth allowing them to cool in the intervals between cutting.

The spindles of circular saws for lumber cutting, or, in fact, for any purpose, should be fitted with the greatest care: the bearings should be long, and provided with oil-chambers and self-oiling devices, to insure lubrication. Every means should be observed to guard against the bearings becoming hot, or even warm, at the end where the saw is supported, for the higher temperature is at once communicated to the centre of the saw-plate, expanding it at this part and causing it to "run." The belts should, in all cases, be wide enough to do the work without either slipping or straining the mandril. A good rule, as to belts, is to have them one-third the diameter of the saw in width, and the diameter of the pulley equal to its face, which, for a 12-inch saw, would give a 4-inch belt on a 4-inch pulley; for large saws, in lumber mills, these proportions would not, of course, apply, but for shop saws it furnishes a safe rule. Until the introduction of band saws there was nothing to compare with the circular saw in the speed of its performance. A good circular saw mill, with ample power, will, in the language of an old lumberman, "saw all the logs that can be brought to it," which was not far from the truth, when we consider that the amount of work done by any circular saw in a given time is never rated by its cutting capacity, but by the facilities or means of handling the material. No operator can keep his saw cutting but a portion of the time, and when we estimate the continuous performance, for 10 hours, of even a small saw, the result is astonishing. The same law cited in reference to reciprocating saws as to the speed of teeth applies here, and, when all things are considered, there seems to be nothing farther to be desired for dividing lumber in straight lines.

Circular saws have never been successfully applied to cutting metal, except for hot bars. Their distinguishing feature, "speed," is not required in the manipulation of metals; but for ivory, bone, leather, paper, &c., circular saws can be used the same as in cutting wood.

The origin of circulars is lost in obscurity; they were introduced, in the year 1790, from Holland, and, as we are informed by a single sentence in regard to the matter, found in an old number of the *Mechanics' Magazine*, "came soon to be generally used."

The system of packing the saw plate, which we have already noticed, came also from Holland.

(To be continued.)

Mechanics, Physics, and Chemistry.

ON THE FOCAL LENGTH OF MICROSCOPIC OBJECTIVES.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.*

By Chas. R. Cross.

The investigation of which the present article is a summary, was undertaken in order to see if some reliable method of measuring the focal length of microscope objectives could not be found. The importance of such a method will be apparent to all who have had occasion to make use of objectives by different makers. The focal length of lenses of the same denomination is subject to so great a variation that comparison of these by means of their assumed focal lengths too often gives no true idea of their relative excellence. For example, if two quarter-inch objectives be compared, and one gives results much superior to that given by the other, we cannot be at all sure that the better lens is not really of shorter focus than its designation would indicate.

The question immediately arises, what is the focal length of a compound objective? The focal length of a simple lens, or of a system of lenses in actual contact, is the distance from the optical centre of that lens or system to its principal focus. But as a system of lenses not in contact, like the triplet objective, has no optical centre, the term is only a general appellation serving to group together objectives of approximately the same magnifying power. If every system of lenses possessed an optical centre, or could be replaced by a single lens, we might define the focal length of such a system as being the focal length of a single lens equivalent to the system in magnifying power. But, as this is not the case, a lens replacing the system when the conjugate foci are separated from each other by a distance, d, will not replace it if the foci are separated by any other distance, d^1; and the difference in focal length of lenses replacing the system under these different circumstances varies with the internal arrangement of the system. But for any constant distance between the conjugate foci any system can be replaced by an equivalent single lens; and in order to attach a definite meaning to the term "focal length," as applied to triplet objectives, I would propose that the focal length of such an objective be understood as being the focal length of a lens replacing the system when the distance between the conjugate foci is ten inches.

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* In a recent number of this *Journal* (March, 1870, p. 208,) attention is called to the great need that is felt of a laboratory for physical research. In 1864, President Rogers, in his plans of this Institute, proposed such a laboratory; and, during the past year, we have fitted up rooms in which our regular students verify many of the laws and measure the principal constants of physics, while more advanced pupils carry on original investigations. In developing the first part of this plan, many unexpected results have been arrived at, and, thinking that they may be of value elsewhere, I hope to make them the subject of a future paper. I think the accompanying article by Mr. Cross will show, that although we cannot always expect to have students with his skill and perseverance, yet that such a laboratory ought to furnish many additions to physical science. E. C. Pickering.

The present series of experiments was begun upon the supposition that a triplet microscope objective has an optical centre, and the formulæ applied to obtain the focal length were based on this supposition, which, on further investigation, proved to be incorrect. Observations recorded in the sequel showed, however, that though not exactly correct, the formulæ offer a very close approximation to the truth for distances of about ten inches between the conjugate foci; the variation in the focal length of the lens replacing the system corresponding to a difference of several inches in that distance being very small.

We may, then, deduce a formula by which to find an equivalent simple lens from the relations between the principal focus, the conjugate foci, and the relative magnitude of object and image for given distances between them.

The principal focus of a simple lens can be determined from the formulæ, $\frac{1}{p} + \frac{1}{p^1} = \frac{1}{f}$, in which p and p^1 are the conjugate force obtained by direct experiment, and f is the principal focus sought. Even if the triple objective had an optical centre, this formulæ could not be applied directly, owing to the practical impossibility of finding this centre, which, moreover, would change with the relative change of position of the lenses composing it in varying the adjustment for different thicknesses of the glass covering the object. The direct use of the formulæ would require the distances p and p^1 to be known. Some modification must, therefore, be adopted.

The method ordinarily in use by the makers seems to be to grind the lenses with certain radii, which are assumed to give approximately definite "focal lengths." The glasses, if tested at all, are compared with some standard objective, by means of their magnifying powers with the same eye-piece, a method liable to considerable errors.

The method which I use is based upon two equations, the one given above, $\frac{1}{p} + \frac{1}{p^1} = \frac{1}{f}$ (1) and $\frac{p}{p^1} = \frac{\text{size of object}}{\text{size of image}} = n$ (2), in which n is the ratio of the size of the object to the size of the image, the conjugate foci being p and p^1. It is clear that though we cannot measure p and p^1 separately, we can measure their sum, that is the distance between the object and the image, which we call l; n can be found by measuring the size of the image of an object of known magnitude, a finely divided scale throwing this image on a second divided scale.

We have from (1) $p^1f + pf^1 = pp^1$, or $lf = pp^1 = (l - p^1)p^1$ (3), as $p + p^1 = l$. But $p = np^1$ from (2); therefore, $p^1 + np^1 = l$, and $p^1 = \frac{l}{n+1}$ (4). Combining (3) and (4) $fl = \frac{nl^2}{(n+1)^2}$, and $f = \frac{nl}{(n+1)^2}$. If, therefore, we find n and l, we can easily find f, the focal length of the equivalent lens.

Two sets of experiments were made with a somewhat different arrangement of apparatus in each. In both the image of a glass scale divided to $\frac{1}{100}$ millimetres ($\frac{1}{2500}$ inch) was thrown upon an engine-divided paper scale ($\frac{1}{50}$ or $\frac{1}{60}$ inch), the image and the paper being in the focus of a double-convex lens used as an eye-piece, so that the size of the magnified image was read directly on the paper scale, estimating by the eye to tenths of the divisions. The distance from the glass to the paper was measured with a steel rule graduated to millimetres. The magnitude of the image varies so slowly for any variation of l that this was taken only in whole millimetres. Any error in the measurement would be less perceptible in the result, the shorter the focus of the lens measured.

The first form of apparatus consists of a stand with a vertical block pierced with two holes, in one of which is placed the objective to be measured with its optical axis horizontal. Through the other hole (the lower one) slides a horizontal bar, at one end of which is the micrometer used as the object, at the other end the paper scale on which the size of the image is measured, reading with an eye-piece detached from the instrument. This bar is moved in either direction until the image is thrown directly on the paper scale, the motion being accomplished by a screw giving a fine adjustment, while the nut in which the screw plays is moved by the hand for the coarse adjustment. The length, l, between the two scales was measured once for all.

The results given by this arrangement were very satisfactory, but owing to its horizontal position and a difficulty in centering the lenses, I afterwards adopted a somewhat different apparatus, with which most of the recorded observations were made. Here I employ a microscope stand, using simply the tube and stage, placing the objective in its usual position, and throwing the image of the micrometer upon the paper scale. The latter is now gummed to the end of the tube usually occupied by the eye-piece, which is replaced by a convex lens detached from the instrument as before. The distance, l, now a variable, has to be measured with each objective. This arrangement can evidently be applied to all microscopes, rendering it possible for any one to determine the focal length of his own objectives with the greatest ease.

The following measurements will show the accuracy of the method:—

Tolles, Second Quality ¼.				Smith and Beck, ¼.			
Apparatus No. 1.		Apparatus No. 2.		Apparatus No. 1.		Apparatus No. 2.	
$l = 311$ mm.		$l = 246$ mm.		$l = 311$ mm.		$l = 253$ mm.	
f.	N.	f.	N.	f.	N.	f.	N.
·2416	20	·2424	30	·2115	20	·2103	40
·2416	10	·2419	50	·2112	30	·2097	40
·2416	20	·2415	50	·2107	30	·2097	40
·2397	20	·2415	40	·2107	30		
M = ·2411		M. = ·2418		·2107	30	M. = ·2099	
P. E. = ·00029		P. E. = ·00011		·2107	30	P. E. = ·00011	
p. e. = ·00058		p. e. = ·00022		·2104	25	p. e. = ·00019	
				·2086	20		
				·2086	20		
				·2079	20		
				M. = ·2095			
				P. E. = ·00025			
				p. e. = ·00084			

The preceding measurements were made with both forms of apparatus, and at an early period of the investigation; the following are by the second method alone, and were taken after considerable practice in using the apparatus.

Hartnack, No. 9.				Tolles, $\frac{1}{12}$.				Nachet, No. 7.			
Adjusted for				Adjusted for				Adjusted for			
Object Covered.		Object Uncovered.		Object Covered.		Object Uncovered.		Object Covered.		Object Uncovered.	
l = 248 mm.		l = 249 mm.		l = 257 mm.		l = 258 mm.		l = 265 mm.		l = 265 mm.	
f.	N.	f.	N.	f.	N.	f.	N.	f.	N.	f.	N.
·0819	10	·0917	10	·0640	10	·0900	15	·0721	10	·0898	15
·0816	10	·0911	10	·0636	10	·0898	15	·0721	10	·0898	15
·0816	10	·0910	10	·0636	10	·0898	15	·0718	10	·0897	10
M. = ·0817		·0910	15	M. = ·0638		M. = ·0899		·0718	10	·0896	15
P. E. = ·00006		M. = ·0912		P. E. = ·00001		P. E. = ·00004		M. = ·0719		M. = ·0897	
p. e. = ·00010		P. E. = ·00009		p. e. = ·00002		p. e. = ·00007		P. E. = ·00005		P. E. = ·00003	
l. = 249 mm.		p. e. = ·00019						p. e. = ·00010		p. e. = ·00006	
f.	N.	l = 264 mm.									
·0817	10	f.	N.								
·0817	10	·0923	10								
·0817	10	·0914	10								
·0817	10	·0911	10								
·0816	10	M. = ·0915									
M. = ·0817		P. E. = ·00020									
P. E. = ·00002		p. e. = ·00035									
p. e. = ·00006											

In the two preceding tables, the focus (*f*) is given in decimals of an inch, as computed from each reading. N is the number of spaces observed on the micrometer scale, and l the distance between the two scales. The most probable mean (M) is computed by giving weight to each observation proportional to the number of spaces (N) taken; that is, assuming that the whole error lies in reading the size of the magnified image on the paper scale. P. E. is the probable error of the mean (M) and *p. e.* that of one observation.

In all the measurements, the objective was refocussed for each reading, and in those given above it was dismounted and remounted for each set.

The table below gives the results of several hundred measurements on various objectives. The first column gives the order in the table for convenience of reference; the second the name of the maker and designation as given by him; the column headed A gives the adjustment, whether for covered or uncovered glass, with the position of the index, if this is present; also whether the lens is wet or dry if an immersion lens. The next column gives in millimetres the distance denoted in the formula by l; that is, the distance between the two scales. The value of f is in all cases the most probable mean of a number of observations. The column headed B gives the focal length indicated by the maker in decimals of an inch. The next column, headed "diff. A.," gives the difference between the actual focal length, as determined by these observations, and the designated focal length as given in column B. The last column, headed "diff. B.," gives the difference in decimals of an inch between the *extreme* values of f as given from different observations by this method.

The micrometer used as an object, was a glass ruled scale divided to $\frac{1}{100}$ mm. ($\frac{1}{2500}$ inch,) except in the objectives numbered 9, 10, 16, 18, 28, 31, 32 (marked with an asterisk) in which a $\frac{1}{1000}$ in. stage micrometer was substituted, as the more finely divided scale could not be read with such low powers as these objectives gave.

Objectives Nos. 16 and 28 are single lenses; the rest are triplets. Lens No. 32, by Zentmayer, had been slightly altered in focal length to adapt it to a gas microscope. The adjustment for covered object shortens the focus of all the glasses examined, except Nos. 11, 12 and 17, in which a lengthening of focus takes place. No. 11 is adjusted for glass covering when the index is at O, contrary to the usual method in which the greater the number of the index the thicker the covering for which the objective is adjusted. Objective No 12 is No. 11 with the front lens removed and an "immersion front," a lens of different focus screwed on in its place.

No.	Name of Maker.	A	l	Focal Length.		B	diff. A.	diff. B.
			mm.	mm.	in.	in.	in.	in.
1 a	Hartnack, No 10.	Unc. Dry.	249	1·985	·0782			·0006
b		Cov'd Dry.	249	1·696	·0668			·0009
c		Unc. Wet.	249	1·991	·0784			·0002
d		Cov'd Wet.	249	1·681	·0662			·0002
2	Hartnack, No. 9.	Unc. Dry.	249	2·317	·0912			·0007
		Unc. Dry.	264	2·325	·0915			·0012
		Cov'd Dry.	218	2·079	·0818			·0003
		Cov'd Dry.	249	2·073	·0816			·0001
		Cov'd Dry.	261	2·079	·0817			·0006
		Unc. Wet.	261	2·339	·0921			·0067
3	Hartnack, $\frac{1}{4}$ in.		249	6·295	·2478	·2500	— ·0022	·0013
4	Hartnack, $\frac{1}{2}$ in.		259	13·659	·5337	·5000	+ ·0337	·0027
5 a	Nachet, No. 7.	Unc'd.	265	2·279	·0897			·0002
b		Cov'd.	265	1·827	·0719			·0003
6	Nachet, No. 5.		264	3·066	·1207			·0004
7	Nachet, No. 3.		235	4·666	·1758			·0004
8	Nachet, No. 2.		239	6·469	·2547			·0006
9*	Nachet, No. 1.		214	14·791	·5823			·0012
10*	Nachet, No. 0.		268	39·163	1·5395			·0027
11 a	Ross' $\frac{1}{12}$ in.	0	249	1·675	·0659			·0004
b		22	250	1·900	·0748	·0833	— ·0085	·0013
12 a	Ross' $\frac{1}{12}$ in., with Immersion Front by Tolles.	0 Dry.	249	1·265	·0498			·0001
b		0 Wet.	249	1·273	·0501			·0006
c		31 Dry.	250	1·696	·0668			·0005
d		31 Wet.	259	1·689	·0665			·0006
13	Smith and Beck, $\frac{1}{5}$ in.		255	4·906	·1931	·2000	— ·0069	·0017
14 a	Smith and Beck, $\frac{1}{4}$ in.	0	253	5·332	·2099	·2500	— ·0401	·0006
b		18	253	5·038	·1983			·0005
15	Smith and Beck, $\frac{2}{3}$ in.		257	16·330	·6429	·6667	— ·0238	·0000
16*	Smith and Beck, $1\frac{1}{2}$ in.	Single Lens.	276	33·990	1·3382	1·5000	— ·1617	·0033

No.	Name of Maker.	A	l	Focal Length.		B	diff. A.	diff. B.
			mm.	mm.	in.	in.	in.	in.
17 a	Collins, $\frac{4}{10}$ in.	3	258	8·180	·3220			·0009
b		20	259	8·502	·3347	·4000	— ·0653	·0010
18*	Collins, $1\frac{1}{2}$ in.		271	42·572	1·6761	1·5000	+ ·1761	.0047
19 a	Spenser, $\frac{1}{2}$ in.	Unc'd.	266	9·717	·3826	·5000	— ·1174	·0000
b		Cov'd.	266	8·947	·3522			·0018
20 a	Tolles, "$\frac{1}{12}$ in. dry, $\frac{1}{15}$ in wet."	0 Dry.	258	2·286	·0899	·0833	+ ·0066	·0002
b		19 Dry.	257	1·620	·0638			·0004
c		6·3. Dry.	256	2·024	·0797			·0012
d		6·3. Wet.	256	1·995	·0786	·0667	+ ·0119	·0003
21	Tolles, $\frac{1}{12}$ in.	0 Dry.	257	2·213	·0871	·0833	+ ·0038	·0011
22	Tolles, $\frac{1}{10}$ in.	0 Dry.	257	2·898	·1141	·1000	+ ·0141	·0014
23 a	Tolles, $\frac{1}{10}$ in.	0 Dry.	258	2·874	·1131	·1000	+ ·0131	·0000
b		14 Dry.	259	2·283	·0899			·0008
c		0 Wet.	258	2·910	·1146	·1000	+ ·0146	·0005
d		14 Wet.	259	2·263	·0891			·0004
24 a	Tolles, $\frac{1}{8}$ in.	0	258	3·217	·1267	·1250	+ ·0017	·0011
b		$16\frac{1}{2}$	258	2·683	·1056			·0005
25 a	Tolles, $\frac{1}{4}$ in.	0	263	6·083	·2395	·2500	— ·0105	·0011
b		10	263	5·675	·2234			·0026
26	Tolles, $\frac{1}{4}$ in., 2d Q.		246	6·143	·2418	·2500	— ·0082	·0009
27	Tolles, $\frac{1}{4}$ in., 2d Q.		248	6·400	·2520	·2500	+ ·0020	·0010
28*	Tolles, 1 in., 2d Q.	Single Lens.	259	25·188	·9916	1·0000	— ·0084	·0000
29 a	Wales, $\frac{4}{10}$ in.	0	258	6·818	·2684	·4000	— ·1316	·0008
b		9	258	6·563	·2584			·0007
30	Zentmayer, $\frac{4}{10}$ in.		255	9·193	·3619	·4000	— ·0381	·0009
31*	Zentmayer, $\frac{8}{10}$ in.		269	20·113	·7918	·8000	— ·0082	·0000
32*	Zentmayer, $1\frac{1}{2}$ in.		280	36·839	1·4504	1·5000	— ·0496	·0022
33 a	Grunow, $\frac{1}{4}$ in.	Unc'd.	273	5·253	·2068	·2500	— ·0432	·0012
b		Cov'd.	273	5·059	·1992			·0003
34	Grunow, $\frac{1}{2}$ in.		255	8·902	·3505	·5000	— ·1495	·0021

The contents of column A may need some further explanation. The immersion lenses were measured both wet and dry to determine the change of focal distance, which is very small unless the interior arrangement of the lenses is altered by moving the index circle. The figures in this column are the numbers given by the index if there was one; if no index was attached to the objective the extremes of the adjustment were taken, and are indicated by the words "Unc." for uncovered, and "Cov'd" for covered adjustment. The $\frac{1}{100}$ millimetre scale used as the object was always uncovered, whether the lens was adjusted for covered and uncovered objects, as no other method seemed so generally applicable. This, of course, rendered the definition somewhat indistinct when the lens was adjusted for glass covering, which will explain the greater difference in the corresponding extreme values of f in the last column.

The measurements in the preceding table were made with the second form of apparatus, so that the length of l varies slightly from the normal length of 10 inches. The extreme values are 276 mm. (10·87 inches) for No. 16 and 235 mm. (9·25 inches) for No. 7. To ascertain the effect of this variation on f, the computed focal distance, the following observations were made. 1st. A Smith and Beck $\frac{1}{4}$ inch (No. 14) was measured, first with $l = 279$ mm. (10·98 inches), and then with $l = 412$ mm. (16·22 inches). The computed values of f in the two cases were—

$$l = 279 \text{ mm.}, f = \cdot 2102 \text{ in.}; \quad l = 412 \text{ mm.}, f = \cdot 2035 \text{ in.},$$

giving a difference of only ·0067 inch in f for a difference of 133 mm. (5·24 inches) in l. 2d. A Tolles second quality $\frac{1}{4}$ inch (No. 26) was measured in the same way, giving values of f as follows:

$$l = 259 \text{ mm.}, f = \cdot 2424 \text{ in.}; \quad l = 414 \text{ mm.}, f = \cdot 2395 \text{ in.}$$

a difference of but ·0029 inches, corresponding to a difference of 155 m m. (6·10 inches) in l. From these results it was inferred that with the maximum deviation (in No. 16) of 22 m m., (0·87 in.) from the normal value of l, the correction required to reduce the value of f to that standard length, would be within the limits of probable error, and in most of the objectives the deviation of l is far less than in this case.

An examination of the table will show that the focal length of the objectives of some makers differs considerably from the length marked upon them. For example, No. 34 marked $\frac{1}{2}$ inch is really a $\frac{1}{3}$ inch objective; No. 33 marked $\frac{1}{4}$ inch is really a $\frac{1}{5}$ inch; No. 29 marked $\frac{4}{10}$ inch is a $\frac{1}{4}$. Lens No. 14 marked $\frac{1}{4}$ inch is really a $\frac{1}{5}$ inch; but Nos. 13, 15, by the same makers, are correctly designated $\frac{1}{5}$ inch, $\frac{2}{3}$ inch. Differences of this kind must of necessity lead to a great confusion in comparing objectives with one another. I would therefore suggest that each objective made should be measured before being offered for sale, that this confusion may cease to exist. A convenient arrangement would be to fix a glass scale divided to $\frac{1}{50}$ or $\frac{1}{100}$ inch in the draw-tube, sliding in the tube of the microscope, and measure as I have already described. The draw-tube should be moved till the front of the ruled glass shall be exactly 10 inches from the micrometer used as the object. Or it would be more convenient still to have an apparatus similar to the first form, but arranged with a suitable stage and stand so that it can be set at any desired angle. The distance 10 inches (254 mm.), suggested as a standard is chosen because it is the normal distance of distinct vision, as well as about the length used by microscopists in actual work.

An inspection of the formula $f = \frac{n\,l}{(n+1)^2}$, shows (1) that the focal length of any lens is not inversely proportional to its magnifying power with a given distance (l) between the conjugate foci, as is commonly assumed, but to $\frac{n}{(n+1)^2}$, the ordinary supposition approaching absolute correctness as n increases. Hence the inaccuracy of any system of estimating focal lengths upon this assumption when applied to lenses of long focus.

(2.) The shorter the focal length of the objective, the less will any error in the measurement of l affect the result.

(3.) Any error in the measurement of n also affects the result less in a lens of short focus. It would therefore appear that by this method the most accurate results are obtained with the objectives of highest power. The following examples from the records of my observations will illustrate this last point. The numerators of the fractions are the readings on the paper scale, the denominators, the number of spaces of the micrometer scale corresponding to these readings, the quotient being of course the value of one of these magnified spaces in fiftieths of an inch.

With objective No. 16*, Smith and Beck, $1\frac{1}{2}$ inch—

Scale readings $\frac{32\cdot8}{11}=2\cdot982$. $\frac{32\cdot7}{11}=2\cdot973$. $\frac{32\cdot7}{11}=2\cdot973$.

Give values of $n=5\cdot964$. 5·946. 5·946.

The corresponding values of f are—

1·3362 inch. 1·3392 inch. 1·3392 inch.

$l=276$ mm. M = 1·3382 in. Differences of extremes = ·0030 in.

With objective No. 8, Nachet No. 2.

Scale readings $\frac{41\cdot2}{60}=\cdot6866$. $\frac{41\cdot2}{60}=\cdot6866$. $\frac{34\cdot4}{60}=\cdot6880$. $\frac{41\cdot3}{60}=\cdot6883$

Give values of $n=34\cdot879$. 34·879. 34·950. 34·965.

The corresponding values of f are—

·25494 inch. ·25494 inch. ·25446 inch. ·25435 inch.

$l=239$ mm. M = ·25466 in. Difference of extremes = ·00059 in.

With objective No. 1, *c*, Hartnack, No. 10.

Scale readings $\frac{36\cdot4}{15}=2\cdot447$. $\frac{24\cdot2}{10}=2\cdot420$. $\frac{36\cdot3}{15}=2\cdot420$. $\frac{36\cdot3}{15}=2\cdot420$.

Give values of $n=123\cdot29$. 122·94. 122·94. 122·94.

The corresponding values of f are—

·07824 inch. ·07845 inch. ·07845 inch. ·07845 inch.

$l=249$ mm. M = ·07839 in. Difference of extremes = ·00021 in.

The increasing change in f for the same variation of the scale reading is clearly seen on comparing the above sets of observations. The diminution of the number of divisions measured in a short focus objective is a partially neutralizing circumstance, which can, however, be avoided by using a lens of long focus for the eye-piece, so as to gain a larger field of view.

The chief difficulty met with in pursuing this research was that of procuring a suitable scale for the object, the image of which was to be meaured. In the earliest measurements a scale on glass ruled to $\frac{1}{1000}$ inches was used, but the lines were jagged at the edges, their breadth was variable and their spacing unequal. Next an eye-piece micrometer belonging to a Smith and Beck's microscope was used, the divisions being $\frac{1}{200}$ inch, but though this was an improvement on the former the results were still unsatisfactory. Finally a micrometer reading to $\frac{1}{100}$ millimetres was used, which was all that could be desired in clearness and evenness of lines and equality of spacing. In some cases, for long focus objectives a $\frac{1}{1000}$ inch micrometer scale was substituted, as before stated. The paper scale used to measure the size of the image was divided to $\frac{1}{50}$ or $\frac{1}{60}$ of an inch, while these divisions were sub-divided by the eye into tenths, giving the measurement to $\frac{1}{500}$ or $\frac{1}{600}$ of an inch. The measurements can in general be relied upon within $\frac{1}{500}$ or $\frac{1}{600}$ of an inch. A scale divided into fractions of a millimetre would have been preferable had such been easily procurable, as saving labor in the calculation of the focal lengths.

Difficulty was at first apprehended from the expansion of the paper scale, especially as this was attached to the microscope tube by mucilage, but measurements made at different times both when moist and when dry showed no appreciable variation to be ascribed to that cause. A steel scale was at one time substituted, but being less easily read, its use was abandoned. A glass scale divided to half millimetres would be valuable in an extensive application of this method, because of the greater ease of estimating to tenths with narrow lines, those on printed scales being necessarily somewhat coarse.

The present investigation has suggested an inquiry into the laws of the foci of systems of lenses as related to variations in the distances between them, which, in connection with the law of variation of focal length with varying values of l, it is my intention to make the subject of further research.

I would take this opportunity of expressing my obligations to the gentleman who have so kindly allowed me the use of their objectives, and especially to Mr. Charles Stodder of the Boston Optical Works for the large number of triplet lenses, by various makers, which he has placed at my disposal.

It is hoped that the method described in this paper may be found of value as offering a ready and reliable method of measuring focal lengths, so that there may be no necessity of doubt as to the true focal length of any objective.

Boston, May 3d, 1870.

A New Use for the Oxyhydrogen Blowpipe.—We observe in a cotemporary that burglars are expected to employ this instrument, furnished with gas compressed in cylinders, to *melt out* locks of safes, &c. From our own experience in attacking large pieces of metal with this instrument, we think no serious alarm need be felt: the rapid removal of the heat by conduction from the part affected would render any extended fusion impossible under the essential conditions of the case.

THE FIRE ALARM TELEGRAPH OF NEW YORK CITY.

(Concluded from page 352.)

The Repeater

is an instrument of great perfection of workmanship and design. It has a very important and exensive work to perform. When it is necessary to send out alarms it is, of course, of first importance to send to the various engine houses, and next to the street boxes. The last signals would be only for the information of the public. The circuit-wheel, driven by regulated clock-work, is here again employed, but it is constructed far differently from that used in the street-boxes. In this case each revolution of the circuit-wheel is made to throw a single signal. In other words, three revolutions will produce three taps of the bells. The signals are usually sent out with a large battery power. It would be expensive to keep up so large a battery power upon every line as is usually thought best to employ for this tapping, so the circuit-wheel is made very broad on the face, and teeth faced with thick platina are placed spirally upon it, and double springs, also heavily armed with platina, are placed so that the teeth come successively up to the springs and throw the battery power into them. Practically, the division is into eight sets of springs and eight sets of teeth on each wheel or roller. As the circuit-wheel or roller revolves it communicates successively the battery power into springs 1 2 3 4 5 6 7 8, and as these springs unite with the lines the power is successively thrown into the eight successive lines. The full power of one large battery is thus brought to bear successively on the different lines in order, and a sufficient number of these circuit wheels, with their springs, are coupled together by gearing, so that all the lines through the city may be charged every revolution. How many of these lines shall be charged is entirely under control. The switch-board allows the operator to throw any number on or off of the repeater. The circuit-wheels are driven by clock-work and weight, and as long as the machine is made to run the wheels would go on to tap regular successive strokes on the bells through the city. But the requirements of the fire service are such that numerical signals from 1 to 998 may be sent out. Any such signal may be sent by the machine—provided that a plan for cutting off the currents from the rollers or circuit-wheels, at regular intervals, be provided. Thus if we wish to send the signal 2 3 we allow the circuit-wheels, in full battery connection, to revolve twice, all the bells on all the lines will tap twice, but as they revolve the third time the battery connection is severed from them, and they revolve inoperative. As they make their fourth revolution the battery power is again turned on and three revolutions are made, giving three more taps. At the conclusion of the third tap the battery is again cut off and remains cut off until it is time to commence a second "round," then the same process is repeated. The cutting off and throwing on of the battery is accomplished by the use of regulating wheels—each one cut to make the different desired signals. These wheels have teeth on them. They can be attached to or detached from the repeater with ease and rapidity. Each tooth passes a certain point in the same space of time occupied by one revolution of the circuit-wheels. The agency of the teeth is to press certain springs together firmly. The springs being fixed, and the wheels revolving, if the first and second tooth of the wheel touch the springs and press them together, the battery power flies to the circuit-wheel. If, however, the next tooth is missing, the springs do not come in contact and the battery is cut off, what signal shall be sent is, therefore, simply a question of how many teeth are left upon the regulating wheels, and in what order they occur. While regulating wheel 3 2 7 is attached to the repeater the instrument cannot send any other signal—it is impossible to make any mistake.

But a difficulty presents itself in carrying out this system of automatic telegraphy. The relation of revolution of the two wheels, that is the regulating and circuit-wheel, must be fixed; in order to send 998 the revolutions must be as 1 to 30, as 30 teeth would be required to send all those 26 taps and the pauses between. It is quite evident, then, that the pause between the completed signal 23 and its repetition is much greater than between 998 and its repetition. It is desirable to have the pauses between rounds equal, and to be able to adjust it to a certain number of seconds. This is accomplished thus:—Instantly after the last stroke of every signal a pin on the regulating wheel actuates a lever which immediately increases the speed of the train, which speed is kept up until the machine stops itself precisely at the point on the regulating wheel where it commenced its action. At the same instant that the speed is increased, another train of wheels is started in action which runs for a certain regulated interval of time and then stops itself, but before stopping itself it restores the parts of the other train to the condition they were before the speed was increased, so that when again it starts it is upon the normal slow speed. The further office of this second train is just, as it is about to complete its action, to start again the first train, so that the complete signal is repeated. Now, as the second train is not tripped until the last working tooth of the regulating wheel acts, the regulating or second train goes into action much sooner on a short signal than on a long one; so that the first train cannot go into action again till the second train stops; so that the effect is after a short signal the first train is tripped and started again almost immediately after it comes to rest; but after a long signal it has to wait until nearly the whole time occupied by the movement of the second train, and thus the pause is completely equalized. These actions of the two trains upon each other continues, and the signals are repeated with great accuracy and uniformity, as long as the trains continue running; but it is arranged that after a certain interval the movement shall lock itself into rest again, so that nothing can again call it into action except the will of the attendant who must make two movements analogous to the setting of a hair trigger and then pulling it. The locking arrangement is contrived so that it can be set to any number of rounds or repetitions of signals required by the department. If set to three, it will complete three rounds and then lock itself, or if set to one, but one alone will be sent.

The object then of the repeater machinery is to send to any number of stations a mechanically correct numerical signal, to repeat it, whether short or long, at regularly timed and equal intervals, and to repeat it as many times as required. This machine does this, requiring that the attendant should perform only two simple operations. First, the attachment of the proper signal wheel. Secondly, the starting of the instrument.

No further attention is required; the operator has his mind relieved at once from responsibility; he may receive a second alarm or attend to other instruments.

Before giving up this instrument to the charge of the Fire Department, it was tested with as much work as would ordinarily be given to it during eighteen months' service. Supplementary to this elaborate instrument is a smaller one for sending any other signals outside of the numerical alarms, such as time signals, or any general orders that are to be sent to engine houses, which can be expressed numerically. It is also ready for use in any emergency which might prevent the use of the larger instrument. All such instruments depend for closing of circuits upon springs which press upon toothed rollers. In these machines these rubbing connections are armed with thick pieces of platina very accurately fitted. The springs are double, either one of the two being competent for the work. The apparatus is closely boxed up in plate glass cases, yet as particles of dust will sometimes get into even such cases, and a chance exists of lessening the perfection of this circuit closing, a test machine is added whereby the exact condition of any spring throughout the apparatus can be ascertained at any time in less than a minute. When not in use each one of the circuit-wheel rollers, with its springs, is switched off from the lines. Attached to the machine, and behind the other works, is a long roller; its office is to press combinations of springs together; if moved twenty degrees the entire eight sets of springs of the first roller are thrown into connection with a battery and a series of eight magnets; if moved forty degrees the second roller is in like manner connected with the battery and the eight magnets and so on through the series.

The effect of this will be when the machine goes through its performance, that these eight magnets will be charged successively instead of eight lines of wires. Now, these eight magnets play the role of ringing eight bells, whose tones correspond with the natural scale so familiar to almost every ear. A break in this scale is very quickly detected. If one note is missing, or is struck unevenly, the spring connected with that note is not perfectly effective. Detection of the slightest imperfection is thus made quick and sure. The entire number of 108 springs could thus, if desired, be tested within ten seconds. To receive the alarms thus sent out by the repeaters, machines are set up in the engine houses and other stations called—

Mechanical Gong Strikers.

These are large gongs struck with a hammer, moved with an apparatus which is driven by a weight, and wound up like a clock. A very delicate trigger is combined with this mechanism, which is capable of very fine adjustment. This trigger is pulled by the magnet and the machine released, and one blow struck. The object of the machine is to give a more or less powerful blow proportioned to the size of the bell, which may weigh from five pounds to ten thousand. The trigger which starts the action is very easily moved.

Such are the principal machines used in the Fire Telegraph, but it is proposed to supplement them with a few circuits independent of the fire lines which may connect all alarm stations, or officers' quarters, with the Central Office, so that special orders, directions for repairs, investigation of difficulties and general discipline, may be easily managed without breaking into the Fire Telegraph lines, which are thus left exclusively for alarms, for although each station may be made a complete telegraph office in emergencies with the facilities provided, it should be used only by the electric corps of management and not by the department generally.

In the very thorough tests made of these lines in order to bring them to perfection, two principals and four subordinate corps of electricians have, with the aid of the most complete apparatus probably ever used for such purposes, reduced the working condition and efficiency of the whole number of lines, from an aggregate imperfection of over 900 degrees to absolute freedom. With this apparently large aggregate escape, or imperfection distributed over all the line, it is quite possible to have all the functions of the lines and apparatus performed; but step by step every cause of disturbance has been so thoroughly removed, that the very last deflection at 3½ degrees is announced by the Electrician-in-Chief to be removed, and not the slightest imperfection exists at the moment of writing these lines.

The system of telegraphy, which is the foundation for this Fire Telegraph, is called the Central Office System of the American Fire Alarm Telegraph, but the special adaption to the requirements of this metropolis, the machines to carry out the modified system, the batteries and the automatic street boxes are the inventions and patents of Charles T. Chester, of the firm of Charles T. & J. N.

Chester, contractors for the construction, under whom the electrical corps have erected and constructed the apparatus. The survey and construction of lines, involving immense labor, has been superintended by Colonel Stephen Chester, of the Engineer Corps, who served, during the war, in the Army of the Potomac.

THE "ANVIL" PROTUBERANCE

Of the Total Eclipse of August 7, 1869, as observed near Sioux City, Iowa, with a four-inch telescope.

By Winthrop S. Gilman, Jr.

The large protuberance visible between angles 230° and 245° in the late Solar Eclipse, and which was so readily seen by the unassisted eye, was, in the telescope, an object of surprising beauty and grandeur. I propose in this paper to notice briefly some of its striking features. The atmosphere of St. Paul Junction, where I observed, was more than usually favorable to good definition, and the performance of my instrument I have never seen surpassed.

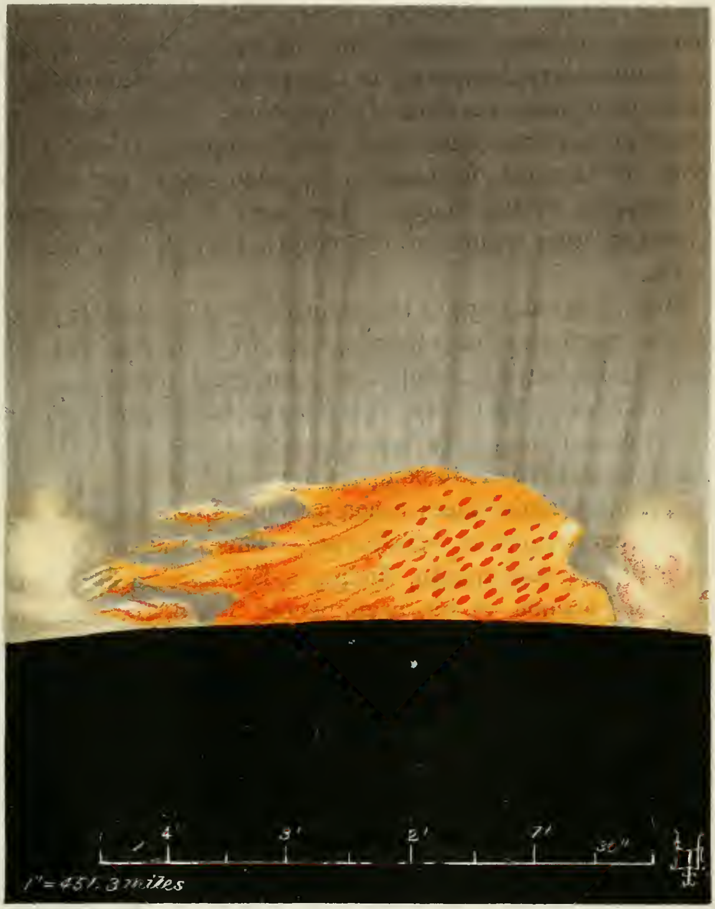
The "Anvil" protuberance was first seen by an assistant with a small glass, several seconds previous to totality, and I could still see it in my instrument when a considerable crescent of the reappearing sun had rendered the corona invisible. Several months study of the sun's surface had prepared me to expect the more remarkable protuberances in the southern hemisphere, and having selected the south-western quadrant as an especially favorable locality, from the presence of faculous ridges near the limb two days prior to the eclipse, the bright, "anvil"-shaped mass instantly attracted my attention. A hasty glance at other portions of the moon's limb satisfied me that the "anvil" protuberance possessed greater interest than any other, and I, therefore, devoted my whole time to its consideration, except so much as was employed in obtaining several outline sketches of the corona.

The limits of the corona were brought into view by a slight movement of the instrument, and its extent was quickly indicated on diagrams previously prepared for the purpose. At the same time I indicated, by two heavy pencil marks, the positions of certain band, or *intervals*, in the light of the corona on opposite sides of the moon's disk. These dark intervals deserve a passing notice.

In my colored sketch of the corona, made immediately after the eclipse, and which accompanies my report published by the Washington Naval Observatory, I have indicated the positions and character of these bands. The absorption bands of the solar spectrum occurred to me at the time as an illustration of the delicate striations in these portions of the corona. In the case of one gap a multitude of fine violet lines were compressed into a space of about 10° in width, forming, to my mind, one of the most beautiful features of the eclipse. The same striated appearance was noticed in other regions of the corona, though in a less striking degree.

These apparent gaps in the corona's light I judged to be opposite elevated portions of the chromosphere, from the fact that there was a similar diminution of light above the great protuberance as my sketches show. This point was not carefully examined, however, from want of time. On my return from the south, in February last, it occurred to me to compare my sketch of the corona with the diagram of protuberances accompanying Prof. Mayer's report in the October number of this *Journal*. This I did, for the first time, on the 9th of that month, finding a fair agreement between the southern portions of his prominences 5 and 10, and the dark bands given in my sketch. I have, therefore, little doubt but that in locating these dark intervals in my original sketches, I intended to place the western one near 285°, and the eastern one near 120°, great exactness not being obtainable in the few moments given to the observation. In speaking of these bands as *dark*, I would be understood only as meaning that they were sufficiently so to be *readily seen*.

Two things specially impressed me in my first view of the so-called "rose colored" protuberances, viz: their *stability* and *non-roseate hue*. In the case of the "anvil" I was further struck by its harshness of outline, which gave an appearance of greater solidity than was expected, and led me to liken the object to a white hot coal.



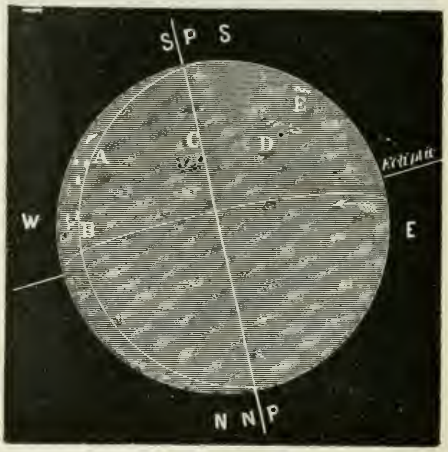
Lith. Jas. McGuigan, Phila.

THE "ANVIL" PROTUBERANCE

OF THE TOTAL ECLIPSE OF AUG. 7 1869 FROM SKETCHES
AND NOTES MADE DURING TOTALITY
AT ST PAUL JUNCN IOWA.
OUTLINE TAKEN FROM THE PHOTOGRAPHS

The plate accompanying this article was prepared from my observations of the great protuberance, with the exception of the outline of the mass, which was obtained from the last Ottumwa photograph of the totality. In preparing this illustration the lithographer has been very successful in copying my sketch, the plate as given recalling the protuberance to my mind with great freshness and power, the original object to me in a most striking manner.—The flaky structure of the protuberance I have endeavored to indicate by a deeper tint of orange running diagonally across the flame. The northern end is more compact than the southern, which latter breaks up into several smaller independent clouds, between which, and suspended fully 10,000 miles above the solar surface, projects the tapering point of the "anvil." A casual glance at the sketch impresses one with the idea of a down-rush of the glowing matter from the northern end towards the "anvil" point. The details of the termination of this tapering end are wholly from my notes which record that this part of the protuberance which was composed of "fibrous lines of flame" apparently in motion, emitting a tremulous light. I have now a vivid recollection of the impressions produced upon my mind by this portion of phenomenon which riveted my attention for some moments. In the photographs the tapering end of the protuberance terminates in a misty ball, which is nothing more than we should expect, if there was motion in the fine lines of light revealed by the telescope.

Fig. 1.



That this vast volume of incandescent gaseous matter had some connection with the dense masses of faculæ indicated at A Fig. 1 in the accompanying sketch of the sun's disk as seen by me on the 5th of August, I have little doubt. The dotted line in this sketch is intended to show the portion of the sun which by virtue of its rotation will coincide with the western limb during the eclipse. A similar dotted line in the sketch of the sun on August 9th, Fig. 2, represents the sun's eastern limb during the eclipse. In this instance we have the faculous ridges marked I, G, F, E which may be referred to prominences 4, 5, 6 and 7 of Prof. Mayer's diagram. It is worthy of special notice that the faculous masses at I are very irregularly disposed, the tortuous windings of its parts suggesting whirling motions in the photosphere. Prof. Mayer's "Eagle" prominence is a fit object to hover over such a curiously agitated portion of the solar surface. That my sketch gives a correct representation of the windings of these ridges of faculæ I feel quite confident. While making the observation the outline was likened to a rude drawing of a camel. The resemblance may appear to some if the page is inverted, the camel being supposed to face to the left.

Fig. 2.

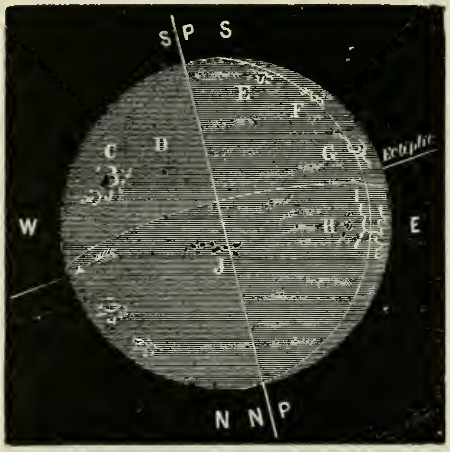
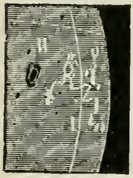


Fig. 3.



A comparison of the Des Moines and Ottumwa pictures of the "anvil" protuberance give the following measurements. It will be noticed that the figures are somewhat in excess of those obtained from the last totality picture made at Burlington.

Extreme length of the "Anvil"	265″ or	119·800 miles.
" " base of the "Anvil"	205″ "	92·500 "
Greatest altitude above the sun's surface	81″ "	36·500 "

Thus if, as is probable, the entire protuberance was not visible, its base being beyond the sun's limb, we have a bright cloud in the solar atmosphere nearly, if not quite, equal in volume to the planet Jupiter, and which in the direction of its length would more than suffice to stretch half-way to the Moon in her perigree.

The tint of the protuberance was according to my estimate a bright *fire-orange*, like the white hot coals of an anthracite grate. Indeed I was struck at my first view of the object with its resemblance to a living coal, in its color, texture and sharpness of outline.

The most remarkable, and at the same time, the most beautiful feature of the flame, consisted of minute deep crimson flakes of a singular brilliancy of hue, which were distributed over its southern part. These flakes stood out against the bright back ground as if totally disconnected from the rest of the phenomenon. In the plate I have endeavored to give their positions and the direction of their axis, which latter coincided with the stratification of the protuberance. I should estimate the length of these brilliant dashes of crimson light at from 3″ to 5″. Possibly in a future eclipse a momentary spectrum of them may be obtained, as their extraordinary brilliancy may make amends for their minute size.

February 24, 1870.

CHEMICAL TABLES ACCORDING TO THE THEORIES OF MODERN CHEMISTRY.

By Prof. Albert R. Leeds.

So long as chemistry was in a transition state between the Theory of Dualistic Combination, the Electro-Chemical Theory of Berzelius and his disciples, (which reigned with an almost absolute sway during the first half of the present century,) and the Unitary Theory evolved by Gerhart, Laurent, Dumas, Hofmann, and other illustrious theorists, chemists might reasonably bear with patience the contradictions and perplexities arising from the unsettled condition of the science. In the opposing rush of contending opinions, the old and well-known landmarks had been swept away, the high-roads of thought had been blocked up by the wrecks of abandoned theories, and little else except the original soil—the facts themselves—remained, upon which the theories of modern chemistry might enter and take undisputed possession. The few who cling to their ancient beliefs have ceased to defend them, and only plead the inaptitude of old age, or the bias of early education, in defence of their loyalty.

But now that the unitary theory has prevailed, it is intolerable that we should be compelled to reason upon and perform the operations of a chemical synthesis or analysis by the formulæ of the old, and compute its numerical results by the data of the new system. Still more so, that we should calculate values for constituents, the bare existence of which has never been demonstrated. As, for example, that we should calculate from the results of an analysis of felspar, its percentage of potash, soda, lime, magnesia, iron and silica, when it has not been proven that any of these compounds exist as such in the felspar. To evaluate the potassium, sodium, calcium, magnesium, aluminum, iron and silicon radicals, and then add the oxygen sufficient to close the atomic group, is all that our present knowledge admits of.

To obviate these difficulties, the table given at the end of the present memoir was all that was originally conceived of. It was designed to give in this table the formulæ and molecular weights of the most important substances, and to adapt it to the ordinary calculus of synthetic and analytical chemistry. But when it became necessary, as a preliminary step in the construction of such a table, to select values for the atomic weights of the elements, a source of great perplexity presented itself. The values given in the most important general works upon chemistry were found, as will be seen by reference to Table II, to exhibit considerable discrepancies, and to differ not only between wide limits, but also without apparent rule. There was no shorter way of solving these difficulties than to examine the sources from which these numbers for the atomic weights were originally drawn. This has been an arduous task, and has carried me far beyond the scope of the first intention. But the pleasure and instruction derived from the critical study of the classic literature of the subject, has more than repaid the outlay of time and labor.

First in order and importance is the chapter on the Bestimmung der Atomgewichte der Grundstoffe, which is given by Berzelius in the third volume of the Leipsic edition of his Lehrbuch der Chemie. His wonderful analytical skill, fertility of invention, close discrimination, and impartial judgment, inspire the chemist with grateful admiration for his great master. The numbers given by Berzelius are taken on the oxygen scale, O = 100. In the Table of Atomic Weights, according to the original observers, I have computed from these numbers their corresponding values on the hydrogen scale, hydrogen being taken as 6·24, the number assigned to it by Berzelius. But in Table III, which I have adopted as a standard, the value of the hydrogen unit on the oxygen scale has been taken as 6·25, in accordance with Dumas. Hence when the atomic weights of Berzelius have been retained, their values have been recalculated on the supposition that the hydrogen unit taken on the oxygen scale is 6·25. This will explain the apparent discrepancies between Tables I and III. Next in importance to the labors of Berzelius, were those of Dumas, which will be found in the Ann. de Chem. [3] I, 5; VIII, 189, and IV, 129. They were undertaken with the purpose of establishing the truth of Prout's law—that the atomic weights of all the elements are multiples by some whole number of that of hydrogen. The numbers which Dumas obtained, compelled him to abandon the law of Prout as originally maintained, and induced him to promulgate it again in a modiform. He brought forward the theory that the elements might be divided into three groups, in the first of which he placed those elements whose at. wts. are multiples of the at. wt. of hydrogen: in the second, those whose at. wts. are multiples of 0·5 the at. wt. of hydrogen: in the third, those whose at. wts. are multiplies of 0·25 the at. wt. of hydrogen. But even then, some deviations from the experimental data was requisite to accommodate his observed to his theoretical at. wts.

Later, a series' of researches was undertaken by Stas, and published under the title of Recherches sur les rapports reciproques des poids atomiques, in the Bull. de l'Acad. r. de Belgique [2] X, (No. 8,) 1860. He redetermined the at. wts. of oxygen, chlorine, sulphur, potassium, sodium, silver and lead, with exceeding care, and exhausted the refinements of chemical art in the purification of his reagents, the variation of his methods, the accuracy of his weighings, and the verification of his results. The differences between the numbers attained by Stas, in a great number of trials for the at. wt. of each of the above-mentioned elements, is less than the differences between the observed at. wt. and the at. wt. which would be required to bring it into conformity with Prout's law. Stas naturally maintained that the at. wts. which he had obtained by unimpeachable experiments should be adopted, in opposition to those supported only by theory. It has been said, in reply, that we must not expect to find in chemistry, any more than in botany and zoology, a law of proportion between parts verified in Nature with mathematical exactness, but only a more or less close approximation; a view certainly of great plausibility, and fortified by abundant analogy. At this point the discussion, for lack of proof more decisive on either side, at present rests.

(To be Continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, April 20th, 1870.

In the absence of the President and Vice-Presidents, the meeting was called to order with Mr. Charles S. Close in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting, held April 13th instant, donations to the library were received from the Royal Astronomical Society, the Royal Institution, the Institute of Actuaries, and the Society of Arts, London; and the Manchester Steam Users' Association, Manchester, England; l'Academie des Sciences, la Société d'Encouragement pour l'Industrie Nationale, Paris; et la Société Industrielles, Mulhouse, France; der Osterreicheschen Ingenieurs-Veriens, Vienna, Austria; Major L. A. Huguet Latour, Montreal, Canada; the Mechanics Institute, San Francisco, Cal.; I. H. C. Coffin, Esq., and Hon. John Lynch, H. R., Washington, D.C.; W. W. Hubbell, Esq., and the Mine Hill and Schuylkill Haven Railroad Company, Philadelphia.

The various Standing Committees reported their minutes.

The Resident Secretary then read his report on Novelties in Science and the Mechanic Arts, after which the meeting was, on motion, adjourned.

Henry Morton, *Secretary.*

Living Organisms in Limestones.—M. Béchamp is the author of an interesting memoir upon this subject, to the French Academy.

He asserts the presence, in the limestones of various geological periods, of living organisms, to which he attaches the name of microzymas.

These microscopic beings he has found, not only in geologically modern deposits, but even in those of Jurassic age. To their presence, he claims, is due the fact that the various limestones, when brought into contact with starch or sugar solutions, cause fermentation to set in; while the same experiment with the highly crystalline varieties of carbonate of lime, produces no trace of such a phenomenon.

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